



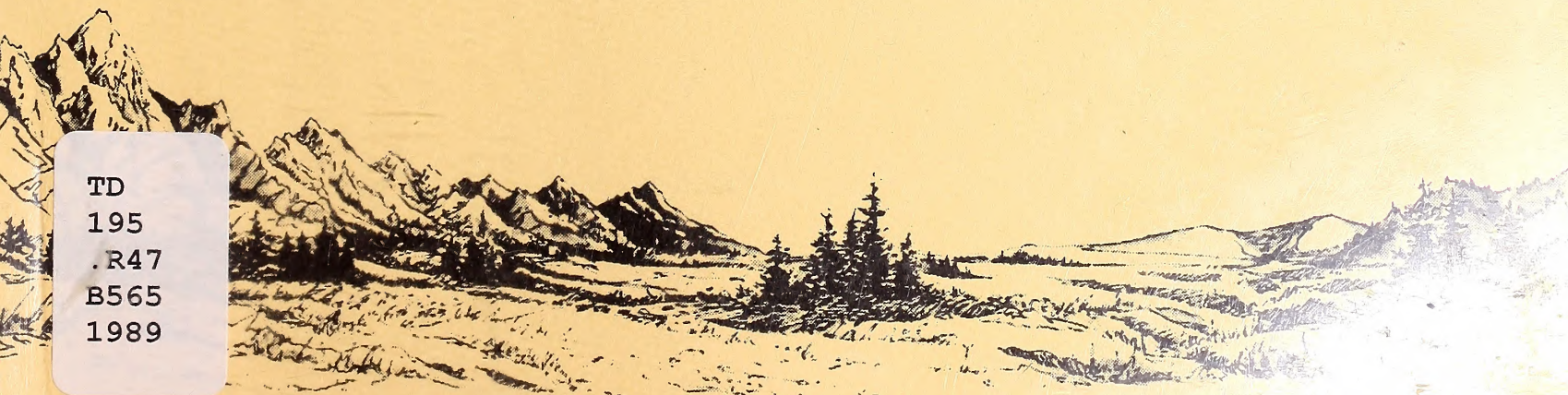
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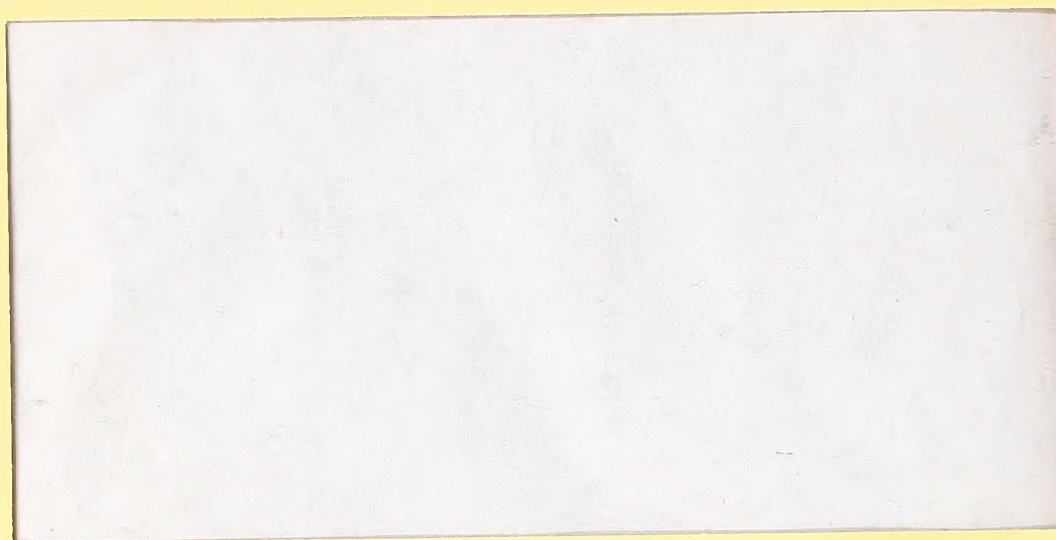
BIOLOGICAL ASSESSMENT
FOR THE
MUDDY CREEK RESERVOIR PROJECT
GRAND COUNTY, COLORADO

BIO/WEST, Inc.

*Resource Management
and Problem Solving Services*

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1989





BIOLOGICAL ASSESSMENT
FOR THE
MUDDY CREEK RESERVOIR PROJECT
GRAND COUNTY, COLORADO

submitted by

Bureau of Land Management
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submitted to

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January 1989

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INTRODUCTION

This Biological Assessment (BA) has been prepared in accordance with Section 7. (c) of the Endangered Species Act of 1973 and evaluates the effects of the proposed Muddy Creek Reservoir on federally listed threatened, endangered and candidate species. Muddy Creek is the site for a reservoir proposed by the Colorado River Water Conservation District (River District). The Muddy Creek Reservoir site is on public lands administered by the Bureau of Land Management (BLM). BLM would be the permitting agency for the Muddy Creek site and is a co-lead agency for the Environmental Impact Statement (EIS) being prepared for the project. The Forest Service, Routt National Forest is also co-lead agency for the EIS. The Muddy Creek alternative has been selected as the agency-preferred alternative for the Rock Creek/Muddy Creek Reservoir EIS. For this reason only the Muddy Creek alternative has been included in this BA.

In a letter dated May 27, 1987, the Fish and Wildlife Service (FWS) indicated that several species should be considered in the BA. Those species, their present listed status, and the conclusions of this BA are listed below.

<u>Common Name</u>	<u>Scientific Name</u>	<u>Status</u>	<u>Impact</u>
Bald Eagle	<u>Haliaeetus leucocephalus</u>	Endangered	May affect
Whooping Crane	<u>Grus americana</u>	Endangered	No effect
Colorado Squawfish	<u>Ptychocheilus lucius</u>	Endangered	May affect
Humpback Chub	<u>Gila cypha</u>	Endangered	May affect
Bonytail Chub	<u>Gila elegans</u>	Endangered	May affect

Two candidate species that were noted in the FWS letter as occurring in the project area are also included in this BA: the razorback sucker (Xyrauchen texanus) and Osterhout's milkvetch (Astragalus osterhoutii).

DESCRIPTION OF THE PROPOSED PROJECT

Purpose and Need for Action

Introduction

The Rock Creek/Muddy Creek EIS was initially undertaken in response to an application submitted to the Forest Service on April 3, 1985, by the Colorado River Water Conservation District (River District) for a Special Use Permit for the construction of a water storage reservoir on Rock Creek, located on National Forest System land within the Yampa Ranger District, Routt National Forest (Applicant's proposed action). Based on the findings of the EIS, the Muddy Creek alternative was selected as the agency-preferred alternative.

The River District, a political subdivision of the State of Colorado, was organized in 1937 under CRS 37-46-101, et seq., and is based in Glenwood Springs, Colorado. In forming the River District, the Colorado General Assembly declared that conservation of the water of the Colorado River in

Colorado for storage, irrigation, mining, and manufacturing purposes and the construction of reservoirs, ditches, and works for the purpose of irrigation and reclamation of additional lands not yet irrigated, as well as to furnish a supplemental supply of water for lands now under irrigation, was of vital importance to the growth and development of the entire district. Also, that the River District is the appropriate agency for the conservation, use, and development of the water resources of the Colorado River and its principal tributaries and should have such powers as may be necessary to safeguard for Colorado all waters to which the State of Colorado is equitably entitled under the Colorado River Compact. The District includes 12 counties and portions of three others which encompass the Upper Colorado River watershed in Colorado. Each county has representation on the River District's Board of Directors.

Among the District's general powers are the powers to make surveys and conduct investigations to determine the best manner of utilizing streamflows within the District, the amount of such streamflow or other water supply, and to locate ditches, irrigation works, and reservoirs to store or utilize water for irrigation, mining, manufacturing, or other purposes. Also included in the District's powers are to make filings upon such water and initiate appropriations for the use and benefit of the ultimate appropriators, and to perform all acts and things necessary or advisable to secure and ensure an adequate supply of water, present and future, for irrigation, mining, manufacturing, and domestic purposes within the District.

The River District proposes to utilize Muddy Creek Reservoir in a manner that meets both Metropolitan Denver and West Slope water demands and that the District considers to be consistent with its statutory mandate. The proposed interim operation of the project involves the lease of a major portion of the reservoir yield to the Denver Water Board for 25 years to be used by Denver to meet water needs in the Denver metropolitan area. Following this 25-year period, Denver could renew the lease for any portion of the firm annual yield that the River District determines is not necessary for western Colorado use.

The proposed reservoir would be utilized to meet the near-term water needs of the Metropolitan Denver Area (MDA). Both the near-term and long-term water needs of the MDA have been analyzed as part of the environmental analysis conducted by the Omaha District Corps of Engineers (COE) as lead agency in the preparation of the Metropolitan Denver Water Supply Environmental Impact Statement (MDWS/EIS). This analysis is included the MDWS/EIS Revised Technical Appendix 2--Future Water Demands and Technical Appendix 3--Existing Water Supply. Both of these appendices are specifically incorporated into this document by reference as provided for by 40 CFR 1502.21. They are available from the Omaha District, U.S. Army Corps of Engineers, P. O. Box 14, Omaha, Nebraska 68101-0014, and may be reviewed at the Forest Supervisor's Office, Routt National Forest, 29887 West U. S. 40, Suite 20, Steamboat Springs, Colorado, or at the BLM Kremmling Resource Area Office, 1116 Park Avenue, Kremmling, Colorado.

History of the Proposed Project

The River District's applications to the Forest Service and the Bureau of Land Management for a special use permit or right of way to build a water

storage reservoir are the result of an extremely complex and lengthy series of legal actions and negotiations involving the adjudication, permitting, and construction of the Windy Gap Project. The Windy Gap Project is a transmountain water diversion project which commenced operation in 1985 and which is owned and operated by the Northern Colorado Water Conservancy District Municipal Subdistrict. After lengthy hearings, the Colorado Supreme Court ruled in 1979 that a conditional water right for the Windy Gap Project could not be granted until the Municipal Subdistrict had defined a plan to adequately mitigate the potential harm to present and prospective water users within the Colorado River drainage basin in Colorado. The River District, along with others, negotiated with the Municipal Subdistrict and came to an agreement in 1980. This agreement called for the Municipal Subdistrict to perform several mitigation measures, including to design, construct, and operate Azure Reservoir on the main-stem Colorado River for the benefit of the economy of the West Slope. From 1981 to 1983, the Municipal Subdistrict conducted numerous engineering and environmental studies on the Azure Project. These studies, along with others by the River District, revealed that the Azure Project should not be pursued due to high cost, local opposition, and disagreement over the size of the reservoir.

The River District and its associates entered a series of negotiations with the Municipal Subdistrict concerning alternatives to the Azure Project. The negotiations resulted in the Azure-Windy Gap Supplemental Agreement of 1985, which was approved by the District Water Court on August 26, 1985. Under this agreement the Municipal Subdistrict provided the River District with a cash payment of \$10,200,000. The River District assumed the responsibility for the permitting, design, and construction of a water storage reservoir as an alternative to Azure.

Project Description

Dam and Reservoir

The site investigated for a reservoir on Muddy Creek lies in a canyon section of the Muddy Creek Valley on the western flank of Wolford Mountain. The site is about 4 miles north of the town of Kremmling, Colorado (Figure 1). Muddy Creek enters the Colorado River at Kremmling, below the confluence with the Blue River and just upstream of Gore Canyon. Much of the information that follows has been extracted from "Report on Feasibility Investigations Rock Creek Dam Project" (Morrison-Knudsen Engineers, Inc., 1986), updated in June 1988.

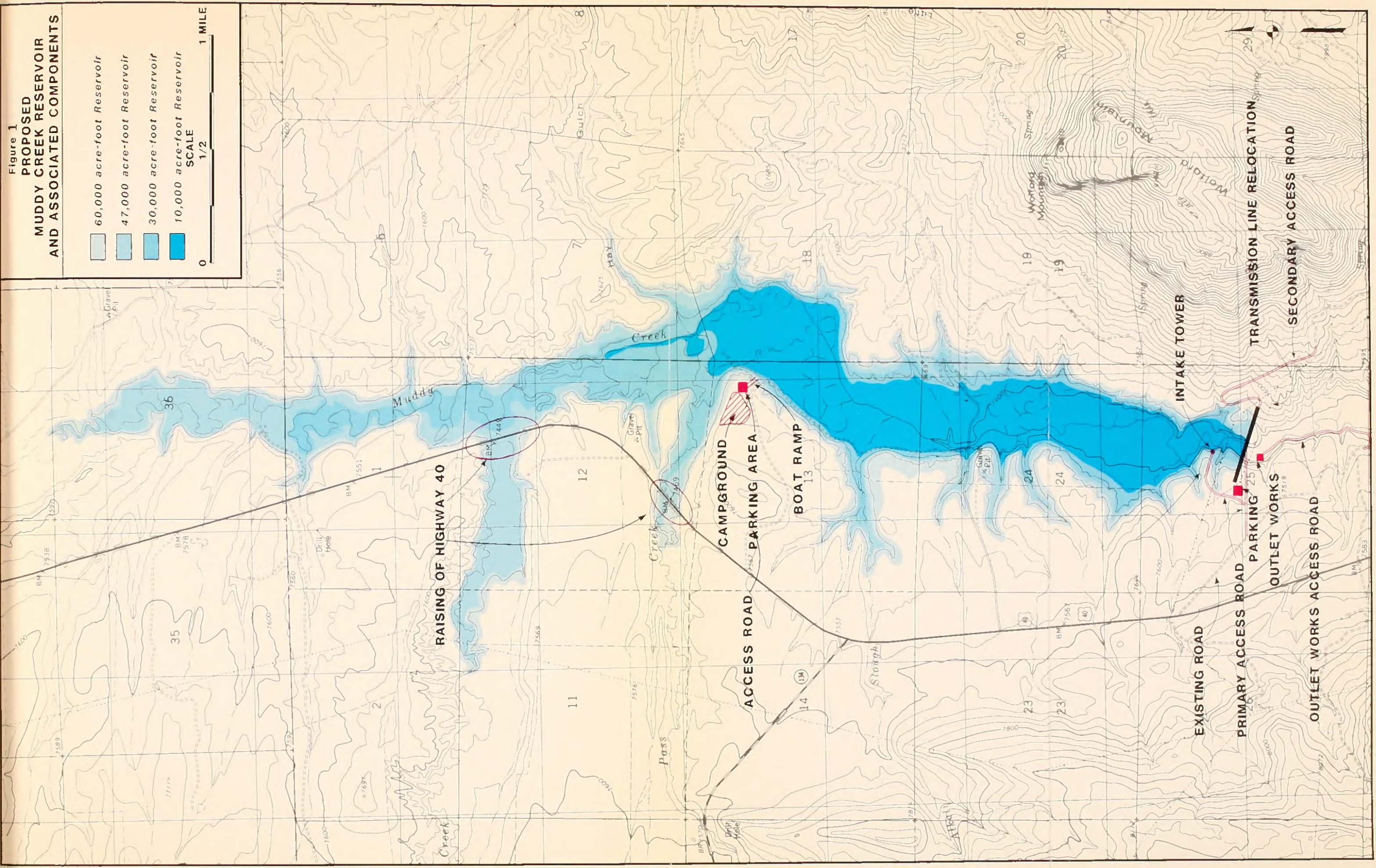
The proposed dam would be an earth embankment dam, rising 120 feet from the streambed to the crest at an elevation of 7500 feet (Figure 2). Crest length would be about 1900 feet, including the service spillway, and the crest width would be 25 feet. The normal operating level would be at 7485 feet, providing a freeboard of 15 feet. The dam would contain a total of approximately 997,200 cubic yards of fill material. The majority of this material would be obtained from borrow areas immediately upstream and downstream of the damsite, resulting in haul distances of less than 1 mile. Approximately 42,800 cubic yards of riprap would have to be hauled 40 miles from a quarry to the east, and a

Figure 1

PROPOSED
MUDDY CREEK RESERVOIR
AND ASSOCIATED COMPONENTS

- 60,000 acre-foot Reservoir
- 47,000 acre-foot Reservoir
- 30,000 acre-foot Reservoir
- 10,000 acre-foot Reservoir

SCALE
1/2
1 MILE



supplier in Kremmling may supply up to 76,700 cubic yards of material, for filters, drains, and concrete aggregate.

At the normal water surface elevation of 7485 feet, the dam would impound 60,000 acre-feet of water, forming a reservoir of 1,447 acres, and extending about 5.5 miles upstream of the dam. The total volume includes approximately 6,000 acre-feet reserved to contain 50 years of silt accumulation from the Muddy Creek basin. Figure 3 provides a conceptual overview of the Muddy Creek dam and reservoir. A 4,000 acre-foot conservation pool is also a feature of the reservoir.

The dam would include a spillway designed to pass a probable maximum flood (PMF) after routing through the reservoir. The PMF for the basin was determined to be 85,400 cfs peak inflow, with a total volume of 33,850 acre-feet. Routing the flood through the reservoir would create a 14-foot rise in reservoir surface level and produce a maximum outflow of 27,665 cfs.

During construction, diversion of the stream would be through a conduit located on the right side of the streambed extending between upstream and downstream cofferdams. The diversion would be sized to accommodate the 10-year spring runoff discharge of about 1,500 cfs. The portion of the conduit passing under the dam would be constructed of cast-in-place concrete on a bench excavated into bedrock on the right abutment. This section of the conduit would be used as the permanent outlet works conduit. After diversion, the conduit would be permanently plugged upstream of the outlet works intake. A temporary bypass would be provided to pass required minimum flows in the interim period between plugging of the diversion channel and reservoir filling to the sill of the intake structure.

The conduit and earth cofferdams would be utilized for the primary streamflow diversion around the Muddy Creek site. Pumped water from the excavated foundation area is expected to be less turbid than the streamflow and will be pumped downstream back into Muddy Creek.

Materials excavated to be used in the dam embankment would come from areas on both abutments which are above the ground-water line. There should be no problem in controlling possible rainfall-induced runoff during construction.

The core material is expected to be obtained from the reservoir area within 1 mile of the dam axis at the west side of the valley floor. This material source is some distance from the main channel and borrow areas will be isolated from the streambed and will not contribute to runoff into Muddy Creek during construction.

The outlet works would consist of an intake tower in the right side of the reservoir upstream of the dam connecting to the conduit passing under the dam and an outlet structure at the downstream toe of the dam (Figure 2). The outlet works would provide a discharge of 400 cfs at minimum reservoir pool. The intake tower would contain four slide gates located at various elevations for selective withdrawal from the reservoir. The feasibility design provides a fifth slide gate for controlling flow to a steel penstock embedded in concrete

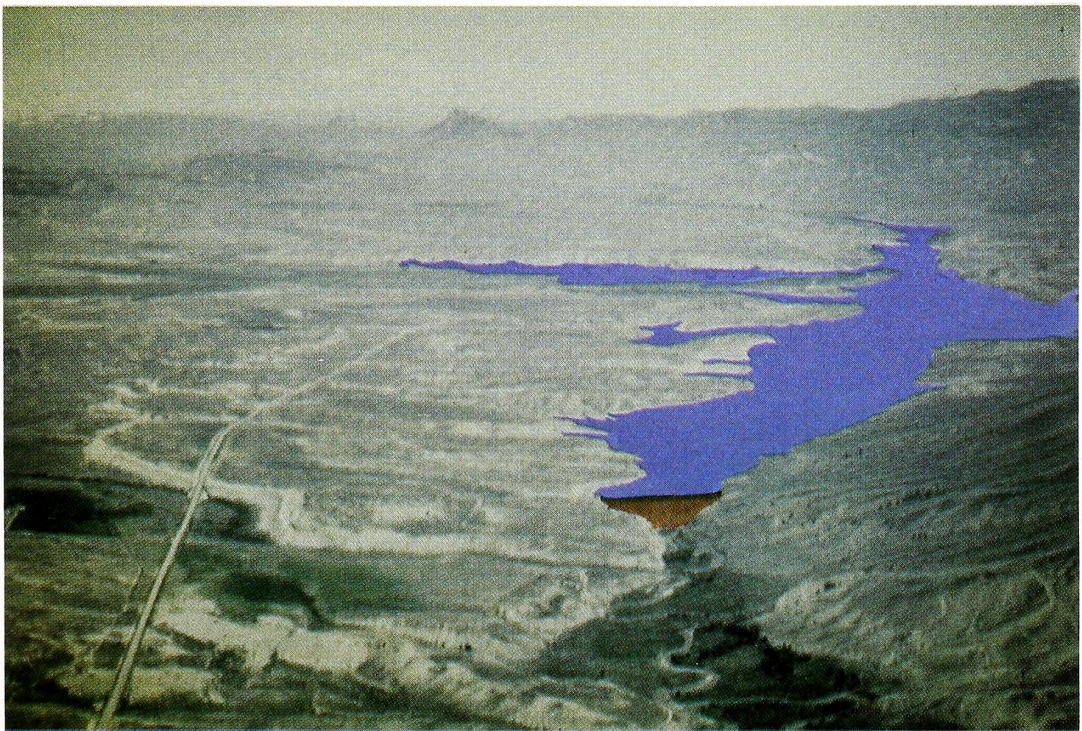


FIGURE 3 - ARTIST'S SIMULATION OF THE PROPOSED MUDDY CREEK RESERVOIR.

adjacent to the outlet conduit. The penstock could be utilized in the future to develop hydroelectric potential at the site.

Access Roads, Relocations, and Recreation Facilities

The proposed Muddy Creek Reservoir would inundate approximately 3500 feet of U.S. Highway 40, and two towers of a 230-kV transmission line. The highway section would be about 16 feet under water at the Red Dirt Creek crossing and would be elevated by an embankment to specifications of the Colorado Division of Highways. The two transmission towers would be relocated just downstream of the dam. Primary access to the dam would consist of a turnoff from U.S. Highway 40 approximately 3 miles north of the town of Kremmling. This primary access road would lead to the dam crest at the right abutment. A secondary access road would be planned (Figure 1) as a continuation of the transmission line road on the eastern side of the reservoir. There would also be secondary access roads from the west side to the outlet works at the toe of the dam.

A campground and picnic ground would be constructed at the area shown on Figure 1. The campground would provide the equivalent of 50 camp units with a 25-site loop and enlarged parking lot for an additional 25 camping spaces. Campsites would include shade shelters. The picnic ground would have 30 to 50 picnic sites and a double lane boat launch ramp. Wells, vault toilets, and a dump station would be provided. Access to the campground/picnic ground would be from Highway 40. A second access from Highway 40 would also be provided to the area below the dam for parking, some picnicking, and fisherman day use.

It is anticipated that the campground and picnic ground would be managed by the State of Colorado, Division of Parks and Outdoor Recreation. Access would be controlled and a use fee would be charged. Fencing would be provided as required to restrict vehicular access to the east and west shores of the proposed reservoir. Figure 1 shows proposed access roads, general location of recreational facilities, and the reservoir perimeter at various reservoir pool levels.

Operating Facilities and Project Administration

The operation, maintenance, and repair of the dam, outlet works, spillway, and other appurtenances would be the responsibility of the River District.

Muddy Creek Construction Planning and Schedule

Materials Sources

Impervious materials for the core would be borrowed from areas upstream from the dam on the right bank, within a half-mile haul. Allowing for stripping of organic material and shrinkage of the impervious core materials, approximately 222,000 cubic yards would be handled to produce 177,800 cubic yards of in-place core. About 714,400 cubic yards of material for the upstream and downstream shells would be borrowed from the right bank immediately upstream and downstream from the damsite. It is possible that materials from the dam foundation excavation and spillway chute would all produce satisfactory shell material.

The remaining portions of the dam embankment consist of the chimney filter, 32,200 cubic yards; blanket drain, 32,000 cubic yards; and riprap, 42,800 cubic yards. The filter materials might possibly be procured from the borrow areas for shell material with screening and processing necessary to meet the specification. Concrete and filter material could be produced onsite or procured locally from a commercial source. There is no known source of riprap available within the Kremmling area. At present construction planning contemplates a quarry source to the east, within a 40-mile haul limit. Roller compacted concrete utilizing locally available material might also be an option for slope protection during final design.

Dam foundation excavation would be waste stockpiled upstream from the dam site, probably within a half-mile haul. This material, if satisfactory for the shell zones, would be hauled back to the dam in lieu of the downstream borrow.

Contractor's Plant and Operations

Specialized equipment would not be required for the earthwork phases of construction. Material would be moved by scrapers and conventional compaction equipment or by front-end loader and off-highway trucks, depending upon what equipment may be available to the successful contractor at the time the work would be performed.

The total excavation is approximately 347,000 cubic yards for the dam foundation, outlet works and spillway structure. Borrow material for the embankment would total another 842,200 cubic yards excluding the filter zones, blanket drain and riprap. The total common excavation, therefore, including the shale for the cutoff trench would be approximate 1,239,200 cubic yards. Most of the excavation would be performed by scrapers and support equipment for haul road maintenance. Embankment compaction equipment would consist of a sheepsfoot roller, a vibrating smooth-drum roller, water trucks for moisture control, grader, and hand compaction for confined areas.

This equipment could construct the dam in one working season if the weather were favorable, a notice to proceed were issued in early March, and stream diversion flow were to fall within a 10-year flood forecast. Total concrete required for the structures would be about 14,500 cubic yards, which, if performed in one season, would require peak placements of 800 cubic yards per week. Planning for a two-season cycle is a more conservative approach.

Construction Schedule

The construction schedule (Figure 4) shows the principal items of work and the sequence of activities based on a two-season approach. The schedule does not account for potential onsite mitigation activities which may arise. For example, excavation of cultural features uncovered during construction activities could be required. During the first year, the diversion of the stream would be accomplished with the upstream and downstream cofferdams, the foundation excavation and the drilling and foundation grouting completed. The inlet tower and outlet stilling basin would be constructed. Depending upon

Construction Schedule

No.	Activity	Quantity	Unit	First Year												Second Year																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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overall progress, the dam embankment would probably be constructed to a height above the original streambed sufficient to protect it from possible flood damage before winter shutdown.

Upon resumption of construction activities in the spring, the balance of the dam embankment, service spillway, and appurtenant structures, would be constructed.

Manpower Estimate and Labor Sources

The estimate of manpower by month is shown for the 2-year duration on Figure 4. The contractor would probably bring his permanent supervisory personnel with him, plus key or lead operators, master mechanic, and key office personnel. Approximately 60 percent of the labor force, consisting of general laborers, carpenters, and heavy equipment operators may be procured locally. No construction camp is contemplated. Workers other than those who live locally would seek housing or trailer sites in Kremmling and other surrounding communities.

Private Land Acquisition

The Muddy Creek site lies on public land administered by the Bureau of Land Management, but much of the reservoir basin is in the private ownership of three ranches. The private lands in and surrounding the reservoir basin consist of about 2-1/2 sections or 1,600 acres. Although not all of these lands would be inundated by the proposed project, it is anticipated that they would all be acquired by the River District to ensure equitable treatment of the landowners. Otherwise, there would be small, isolated parcels of private land, an undesirable situation for both the landowner and the reservoir operator.

Muddy Creek Reservoir Operations Summary

Under Colorado's system of water law, those water users with the most senior priority dates get the first call on available water. For this reach of the Colorado River, the senior water rights at Cameo (collectively about 2200 cfs with pre-1920 priority dates) or Shoshone Power Plant (about 1250 cfs with a priority date of 1902) control the administration of the river. Diversions junior to the Shoshone and Cameo rights need to provide augmentation water for periods when their junior right is "out of priority". Thus, Muddy Creek would be primarily a source of augmentation water. When releases are made from the proposed reservoir in exchange for water stored in Green Mountain Reservoir, those releases would be controlled by the Bureau of Reclamation as though the water were stored in Green Mountain Reservoir. The anticipated operations of Muddy Creek Reservoir under a Metro Denver Lease are illustrated in Table 1 for the period 1962-1982. Table 2 shows the effect of Muddy Creek's operation on the Colorado River at Dotsero. Flow changes would generally be less than 1 percent, with a maximum change of -11.33 percent in May 1978.

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Table 1

MUDDY CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

		---WEST SLOPE DEMAND---			---METRO DENVER LEASE---			
WATER	INFLOW	FLOW	DIFF	PERCENT	FLOW	DIFF	PERCENT	
YEAR	TO	BELOW	IN	CHANGE	BELOW	IN	CHANGE	
	RES	RES	FLOW		RES	FLOW		
	CFS	CFS	CFS	%	CFS	CFS	%	
COL	1	2	3	4	5	6	7	
1962	OCT	77	77	0	0	13	-64	-83
	NOV	61	80	20	33	65	4	7
	DEC	35	54	19	55	39	4	12
	JAN	53	72	19	36	57	4	8
	FEB	50	71	21	43	54	5	9
	MAR	29	48	19	67	33	4	14
	APR	539	439	-99	-18	405	-134	-25
	MAY	536	536	0	0	536	0	0
	JUN	238	238	0	0	238	0	0
	JUL	108	150	42	38	195	87	80
	AUG	59	148	89	150	98	39	67
	SEP	31	51	20	64	35	4	14
1963	OCT	0	19	19	1000*	13	13	1000*
	NOV	0	20	20	1000*	13	13	1000*
	DEC	0	19	19	1000*	13	13	1000*
	JAN	34	53	19	57	38	4	12
	FEB	47	68	21	46	51	5	10
	MAR	77	96	19	25	81	4	5
	APR	110	130	20	18	115	4	4
	MAY	144	13	-131	-91	46	-98	-68
	JUN	38	13	-25	-66	38	0	0
	JUL	17	150	133	779	100	83	486
	AUG	33	53	19	57	163	130	389
	SEP	2	22	20	976	121	119	5859
1964	OCT	16	35	19	122	156	141	894
	NOV	28	48	20	72	32	4	15
	DEC	22	41	19	87	26	4	18
	JAN	21	40	19	90	25	4	19
	FEB	23	44	21	94	27	5	20
	MAR	27	46	19	71	31	4	15
	APR	80	99	20	25	84	4	5
	MAY	201	13	-188	-94	13	-188	-94
	JUN	151	13	-138	-91	13	-138	-91
	JUL	58	150	92	159	100	42	73
	AUG	87	148	61	70	136	49	57
	SEP	12	32	20	161	237	225	1830

1000* actual value equal to infinity

Table 1 (continued)

MUDDY CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

		---WEST SLOPE DEMAND---			---METRO DENVER LEASE---			
WATER YEAR	INFLOW TO RES	FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE	FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE	
	CFS	CFS	CFS	%	CFS	CFS	%	
COL	1	2	3	4	5	6	7	
1965	OCT	18	37	19	106	52	34	187
	NOV	23	43	20	87	27	4	18
	DEC	19	38	19	103	23	4	22
	JAN	17	36	19	111	21	4	23
	FEB	18	39	21	118	22	5	25
	MAR	15	34	19	125	19	4	27
	APR	134	154	20	15	138	4	3
	MAY	347	13	-334	-96	13	-334	-96
	JUN	349	261	-88	-25	138	-211	-61
	JUL	97	150	53	54	100	3	3
	AUG	99	148	49	49	98	-1	-1
	SEP	57	77	20	35	62	4	7
1966	OCT	60	80	19	32	64	4	7
	NOV	54	74	20	37	58	4	8
	DEC	26	45	19	74	30	4	16
	JAN	44	63	19	44	48	4	9
	FEB	30	51	21	71	34	5	15
	MAR	64	83	19	30	68	4	6
	APR	77	97	20	26	81	4	5
	MAY	109	13	-96	-88	74	-35	-32
	JUN	15	19	4	28	19	4	28
	JUL	5	150	145	2821	100	95	1848
	AUG	4	23	19	535	98	95	2643
	SEP	15	35	20	131	88	73	479
1967	OCT	40	59	19	48	44	4	10
	NOV	43	62	20	46	47	4	10
	DEC	25	44	19	76	29	4	16
	JAN	24	43	19	81	28	4	17
	FEB	32	53	21	66	36	5	14
	MAR	80	99	19	24	84	4	5
	APR	100	119	20	20	104	4	4
	MAY	154	13	-141	-92	13	-141	-92
	JUN	180	13	-167	-93	23	-157	-87
	JUL	59	150	91	156	100	41	70
	AUG	49	68	19	39	123	74	150
	SEP	47	66	20	43	144	97	209

Table 1 (continued)

MUDDY CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

---WEST SLOPE DEMAND---					---METRO DENVER LEASE---			
WATER YEAR	INFLOW TO RES	FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE	FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE	
	CFS	CFS	CFS	%	CFS	CFS	%	
COL	1	2	3	4	5	6	7	
1968	OCT	31	51	19	61	105	74	235
	NOV	38	58	20	52	43	4	11
	DEC	35	54	19	55	39	4	12
	JAN	46	65	19	42	50	4	9
	FEB	52	73	21	41	56	5	9
	MAR	49	68	19	39	53	4	8
	APR	99	119	20	20	103	4	4
	MAY	209	13	-196	-94	13	-196	-94
	JUN	280	26	-254	-91	165	-115	-41
	JUL	94	150	56	60	100	6	6
	AUG	113	148	35	31	192	79	70
	SEP	51	71	20	39	55	4	8
1969	OCT	45	64	19	43	49	4	9
	NOV	64	84	20	31	68	4	7
	DEC	54	73	19	36	58	4	8
	JAN	49	68	19	39	53	4	8
	FEB	47	68	21	45	52	5	10
	MAR	52	71	19	37	56	4	8
	APR	161	20	-141	-88	132	-29	-18
	MAY	190	102	-88	-46	190	0	0
	JUN	144	144	0	0	144	0	0
	JUL	68	150	82	119	100	32	46
	AUG	17	148	130	750	98	81	467
	SEP	27	46	20	75	31	4	16
1970	OCT	76	96	19	25	80	4	5
	NOV	61	81	20	33	65	4	7
	DEC	57	77	19	33	61	4	7
	JAN	60	79	19	32	64	4	7
	FEB	48	69	21	44	53	5	9
	MAR	63	82	19	31	67	4	6
	APR	159	178	20	13	163	4	3
	MAY	494	129	-365	-74	349	-145	-29
	JUN	348	348	0	0	348	0	0
	JUL	125	150	25	20	212	87	70
	AUG	74	148	73	99	98	24	33
	SEP	28	48	20	70	32	4	15

Table 1 (continued)

MUDDY CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

		---WEST SLOPE DEMAND---			---METRO DENVER LEASE---			
WATER YEAR	INFLOW TO RES	FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE	FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE	
	CFS	CFS	CFS	%	CFS	CFS	%	
COL	1	2	3	4	5	6	7	
1971	OCT	99	118	19	19	103	4	4
	NOV	107	127	20	19	111	4	4
	DEC	85	104	19	23	89	4	5
	JAN	84	104	19	23	89	4	5
	FEB	100	121	21	21	104	5	5
	MAR	110	130	19	17	114	4	4
	APR	145	20	-125	-86	90	-54	-38
	MAY	212	99	-113	-53	212	0	0
	JUN	306	306	0	0	306	0	0
	JUL	319	450	131	41	406	87	27
	AUG	153	172	19	13	157	4	3
	SEP	120	140	20	16	125	4	3
1972	OCT	63	82	19	30	67	4	6
	NOV	44	63	20	45	48	4	10
	DEC	55	75	19	35	60	4	7
	JAN	28	47	19	68	32	4	14
	FEB	44	65	21	48	49	5	10
	MAR	78	97	19	25	82	4	5
	APR	123	143	20	16	127	4	3
	MAY	277	104	-173	-62	240	-37	-13
	JUN	262	262	0	0	262	0	0
	JUL	71	150	79	110	100	29	40
	AUG	41	148	106	258	98	57	139
	SEP	39	59	20	51	43	4	11
1973	OCT	55	75	19	35	59	4	7
	NOV	39	59	20	50	44	4	11
	DEC	17	37	19	110	22	4	23
	JAN	11	30	19	180	15	4	38
	FEB	9	30	21	243	13	5	52
	MAR	14	33	19	138	18	4	29
	APR	107	127	20	19	111	4	4
	MAY	451	113	-339	-75	333	-118	-26
	JUN	298	298	0	0	298	0	0
	JUL	148	150	2	1	235	87	59
	AUG	89	148	59	66	98	9	11
	SEP	37	57	20	53	42	4	11

Table 1 (continued)

MUDDY CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

		---WEST SLOPE DEMAND---			---METRO DENVER LEASE---			
WATER	INFLOW	FLOW	DIFF	PERCENT	FLOW	DIFF	PERCENT	
YEAR	TO	BELOW	IN	CHANGE	BELOW	IN	CHANGE	
	RES	RES	FLOW		RES	FLOW		
	CFS	CFS	CFS	%	CFS	CFS	%	
COL	1	2	3	4	5	6	7	
1974	OCT	37	56	19	52	41	4	11
	NOV	48	68	20	41	52	4	9
	DEC	47	66	19	41	51	4	9
	JAN	48	67	19	40	52	4	9
	FEB	40	61	21	53	45	5	11
	MAR	80	99	19	24	84	4	5
	APR	143	163	20	14	147	4	3
	MAY	467	253	-214	-46	425	-42	-9
	JUN	225	225	0	0	225	0	0
	JUL	110	150	40	36	197	87	79
	AUG	54	148	94	176	98	45	84
	SEP	7	27	20	266	13	6	74
1975	OCT	45	64	19	43	49	4	9
	NOV	52	71	20	38	56	4	8
	DEC	37	56	19	52	41	4	11
	JAN	30	49	19	64	34	4	14
	FEB	38	59	21	56	43	5	12
	MAR	48	67	19	40	52	4	8
	APR	99	119	20	20	103	4	4
	MAY	330	42	-287	-87	251	-79	-24
	JUN	394	394	0	0	394	0	0
	JUL	122	150	28	23	209	87	71
	AUG	78	148	70	90	98	21	27
	SEP	36	56	20	55	40	4	12
1976	OCT	49	68	19	39	53	4	8
	NOV	58	78	20	34	62	4	7
	DEC	68	87	19	28	72	4	6
	JAN	60	80	19	32	64	4	7
	FEB	57	78	21	37	61	5	8
	MAR	83	102	19	23	87	4	5
	APR	130	150	20	15	134	4	3
	MAY	292	40	-251	-86	238	-53	-18
	JUN	132	132	0	0	132	0	0
	JUL	56	150	94	166	100	44	77
	AUG	54	148	94	175	98	45	84
	SEP	31	51	20	64	35	4	14

Table 1 (continued)

MUDDY CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

		---WEST SLOPE DEMAND---			---METRO DENVER LEASE---			
WATER YEAR	INFLOW TO RES	FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE	FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE	
	CFS	CFS	CFS	%	CFS	CFS	%	
COL	1	2	3	4	5	6	7	
1977	OCT	39	58	19	49	43	4	10
	NOV	31	51	20	63	36	4	13
	DEC	49	68	19	39	53	4	8
	JAN	10	29	19	188	14	4	40
	FEB	30	51	21	71	34	5	15
	MAR	32	52	19	59	37	4	13
	APR	88	108	20	22	93	4	5
	MAY	67	71	4	6	71	4	6
	JUN	14	18	4	30	18	4	30
	JUL	16	36	19	117	211	195	1184
	AUG	27	70	43	157	352	325	1191
	SEP	17	69	52	303	54	36	212
1978	OCT	36	77	40	112	61	25	70
	NOV	32	66	34	105	50	18	56
	DEC	24	55	31	129	40	16	67
	JAN	39	67	28	71	52	13	32
	FEB	40	65	26	64	49	9	22
	MAR	72	93	21	30	78	6	9
	APR	183	212	29	16	196	13	7
	MAY	415	13	-402	-97	13	-402	-97
	JUN	395	122	-273	-69	13	-382	-97
	JUL	121	150	29	24	197	76	63
	AUG	49	148	98	200	98	49	100
	SEP	18	38	20	112	56	38	216
1979	OCT	43	62	19	44	47	4	9
	NOV	52	72	20	38	56	4	8
	DEC	62	82	19	31	66	4	7
	JAN	51	70	19	37	55	4	8
	FEB	53	74	21	40	57	5	8
	MAR	39	58	19	49	43	4	10
	APR	152	171	20	13	156	4	3
	MAY	597	316	-281	-47	483	-115	-19
	JUN	422	422	0	0	422	0	0
	JUL	91	150	59	64	100	9	10
	AUG	71	148	77	108	98	27	38
	SEP	4	24	20	505	13	9	231

Table 1 (continued)

MUDDY CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

		---WEST SLOPE DEMAND---			---METRO DENVER LEASE---			
WATER	INFLOW	FLOW	DIFF	PERCENT	FLOW	DIFF	PERCENT	
YEAR	TO	BELOW	IN	CHANGE	BELOW	IN	CHANGE	
	RES	RES	FLOW		RES	FLOW		
	CFS	CFS	CFS	%	CFS	CFS	%	
COL	1	2	3	4	5	6	7	
1980	OCT	27	46	19	71	31	4	15
	NOV	47	67	20	42	52	4	9
	DEC	38	57	19	51	42	4	11
	JAN	46	65	19	42	50	4	9
	FEB	45	66	21	47	49	5	10
	MAR	39	58	19	50	43	4	11
	APR	151	171	20	13	155	4	3
	MAY	512	224	-289	-56	439	-73	-14
	JUN	169	169	0	0	169	0	0
	JUL	77	150	73	94	100	23	30
	AUG	79	148	69	87	98	20	25
	SEP	31	51	20	64	35	4	14
1981	OCT	47	66	19	41	51	4	9
	NOV	46	66	20	43	50	4	9
	DEC	38	57	19	51	42	4	11
	JAN	36	55	19	54	40	4	11
	FEB	52	73	21	41	56	5	9
	MAR	44	64	19	43	48	4	9
	APR	58	77	20	34	62	4	7
	MAY	115	13	-102	-89	40	-75	-65
	JUN	74	13	-61	-82	74	0	0
	JUL	77	150	74	96	100	24	31
	AUG	41	148	107	264	387	346	854
	SEP	36	56	20	55	40	4	12
1982	OCT	59	78	19	33	63	4	7
	NOV	55	75	20	36	59	4	8
	DEC	48	67	19	40	52	4	8
	JAN	60	79	19	32	64	4	7
	FEB	49	70	21	44	53	5	9
	MAR	24	43	19	81	28	4	17
	APR	43	63	20	46	47	4	10
	MAY	270	13	-257	-95	13	-257	-95
	JUN	298	80	-219	-73	149	-150	-50
	JUL	106	150	44	42	193	87	82
	AUG	39	148	108	274	98	59	150
	SEP	51	20	-31	-61	13	-38	-75
AVERAGE	94	95	1	1	94	2	3	
MINIMUM	0	13	-402	-97	13	-402	-97	
MAXIMUM	597	536	145	2821	543	346	5859	

Table 1 (continued)

MUDDY CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

WATER YEAR	INFLOW TO RES	---WEST SLOPE DEMAND---			---METRO DENVER LEASE---		
		FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE	FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE
	CFS	CFS	CFS	%	CFS	CFS	%
COL	1	2	3	4	5	6	7
1962	151	164	12	8	151	0	0
1963	42	55	13	31	66	24	58
1964	60	59	-1	-2	68	8	13
1965	100	86	-14	-14	68	-32	-32
1966	42	61	19	46	56	14	34
1967	69	66	-3	-5	69	-0	-1
1968	91	75	-17	-18	78	-13	-15
1969	77	87	10	13	77	0	0
1970	133	124	-9	-7	133	0	0
1971	153	158	4	3	153	0	0
1972	94	108	14	15	94	0	0
1973	106	96	-10	-9	106	0	0
1974	109	115	6	6	109	0	0
1975	109	106	-3	-2	109	-0	-0
1976	89	97	8	9	89	0	0
1977	35	57	22	61	81	46	129
1978	119	92	-27	-22	77	-41	-35
1979	136	137	1	1	133	-4	-3
1980	105	106	1	1	104	-1	-1
1981	55	70	15	27	86	31	56
1982	92	74	-18	-20	61	-31	-34
AVERAGE	94	95	1	1	94	0	0
MINIMUM	35	55	-27	-22	153	-41	-35
MAXIMUM	153	164	22	61	56	46	129

6/20/88

Table 2

Muddy Creek Reservoir Analysis
 -- Colorado River At Dotsero Gage --

Water Year	Month	West Slope Demand					Metro Denver Lease		
		Historic Dotsero Flows (cfs)	Simulated Base Flows (cfs)	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
1962	OCT	1947	1789	1783	-6	-0.34	1720	-70	-3.90
	NOV	1366	1423	1429	6	0.45	1413	-9	-0.65
	DEC	1229	1173	1180	7	0.60	1165	-8	-0.69
	JAN	1264	1165	1173	8	0.68	1157	-7	-0.61
	FEB	1603	1397	1411	14	0.98	1394	-3	-0.22
	MAR	1961	1408	1422	14	0.96	1406	-2	-0.12
	APR	5601	4794	4695	-99	-2.07	4660	-134	-2.80
	MAY	8600	6718	6709	-9	-0.13	6709	-9	-0.13
	JUN	7243	6340	6333	-7	-0.11	6333	-7	-0.11
	JUL	4598	4144	4184	40	0.97	4229	86	2.06
	AUG	1737	1546	1639	93	6.04	1590	44	2.86
	SEPT	1185	995	1018	24	2.40	1003	8	0.83
1963	OCT	2038	1194	1209	15	1.23	1203	8	0.71
	NOV	1664	1230	1231	1	0.10	1224	-6	-0.46
	DEC	1100	996	998	2	0.20	992	-4	-0.43
	JAN	835	994	997	3	0.28	982	-12	-1.24
	FEB	887	954	969	15	1.57	952	-2	-0.19
	MAR	961	1011	1026	15	1.50	1011	0	0.00
	APR	1300	1411	1433	22	1.56	1417	6	0.45
	MAY	2461	2233	2098	-135	-6.04	2131	-102	-4.58
	JUN	1923	1906	1877	-29	-1.52	1902	-4	-0.22
	JUL	1021	1122	1251	129	11.49	1151	29	2.58
	AUG	1217	1536	1560	24	1.57	1545	9	0.58
	SEPT	1219	1156	1180	24	2.06	1164	8	0.71
1964	OCT	967	1068	1082	14	1.36	1067	-1	-0.06
	NOV	875	946	946	1	0.07	931	-15	-1.58
	DEC	589	758	759	1	0.15	744	-14	-1.85
	JAN	563	734	736	2	0.29	721	-13	-1.77
	FEB	571	597	612	15	2.47	595	-2	-0.33
	MAR	610	585	600	15	2.58	585	-0	-0.00
	APR	1039	1030	1052	22	2.14	1036	6	0.62
	MAY	3179	2745	2553	-192	-6.99	2553	-192	-6.99
	JUN	3400	3173	3031	-142	-4.47	3031	-142	-4.47
	JUL	1544	1395	1483	88	6.31	1433	38	2.73
	AUG	1352	1149	1215	66	5.72	1158	9	0.78
	SEPT	1177	1013	1037	24	2.36	1021	8	0.81
1965	OCT	1015	1001	1015	14	1.43	1000	-1	-0.08
	NOV	814	896	897	1	0.06	881	-15	-1.69
	DEC	789	829	830	1	0.14	815	-14	-1.69
	JAN	743	786	788	2	0.27	773	-13	-1.66
	FEB	731	789	797	8	1.00	780	-9	-1.12
	MAR	755	808	819	12	1.45	804	-3	-0.42
	APR	1711	1528	1539	12	0.76	1524	-4	-0.26
	MAY	4123	3514	3175	-339	-9.63	3175	-339	-9.63
	JUN	7055	6634	6536	-98	-1.48	6413	-221	-3.33
	JUL	4189	3550	3600	50	1.42	3550	0	0.01
	AUG	2735	2352	2390	39	1.65	2341	-10	-0.44
	SEPT	1535	1419	1443	24	1.68	1427	8	0.58
1966	OCT	1517	1519	1535	16	1.05	1520	1	0.05
	NOV	1405	1445	1449	4	0.26	1433	-12	-0.83
	DEC	1389	1319	1323	4	0.33	1308	-11	-0.81
	JAN	1223	1192	1197	5	0.45	1182	-10	-0.82
	FEB	1223	1020	1036	15	1.52	1019	-1	-0.12
	MAR	1434	1185	1200	15	1.28	1185	0	0.00
	APR	1365	1323	1345	22	1.66	1329	6	0.48
	MAY	2760	2425	2325	-100	-4.12	2386	-39	-1.59
	JUN	1706	1697	1697	-0	-0.00	1697	-0	-0.00
	JUL	1404	1150	1291	141	12.25	1224	74	6.43
	AUG	1237	1127	1151	24	2.13	1156	29	2.58
	SEPT	1142	1222	1245	24	1.95	1230	8	0.67

Table 2 (continued)

Muddy Creek Reservoir Analysis
-- Colorado River At Dotsero Gage --

Water Year	Month	West Slope Demand					Metro Denver Lease		
		Historic Dotsero Flows (cfs)	Simulated Base Flows (cfs)	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	1047	1029	1044	14	1.41	1029	-1	-0.06
	NOV	811	820	821	1	0.08	805	-15	-1.82
	DEC	659	665	666	1	0.17	651	-14	-2.10
	JAN	734	695	697	2	0.31	682	-13	-1.87
	FEB	751	629	644	15	2.38	628	-2	-0.29
	MAR	1031	924	939	15	1.64	924	0	0.00
1967	APR	1580	1497	1519	22	1.47	1504	6	0.43
	MAY	2641	2262	2117	-145	-6.41	2117	-145	-6.41
	JUN	3927	3340	3169	-171	-5.12	3179	-161	-4.81
	JUL	2051	1756	1844	87	4.97	1794	37	2.12
	AUG	1288	1198	1222	24	2.01	1207	9	0.75
	SEPT	1271	1210	1234	24	1.97	1218	8	0.68
	OCT	1084	1108	1121	13	1.14	1106	-2	-0.22
	NOV	1004	1061	1058	-3	-0.27	1043	-18	-1.74
	DEC	888	988	990	2	0.23	975	-13	-1.30
	JAN	779	891	895	3	0.37	880	-12	-1.33
	FEB	882	835	851	15	1.81	834	-2	-0.19
	MAR	913	781	797	15	1.93	781	-0	-0.00
1968	APR	1453	1027	1049	22	2.14	1033	6	0.62
	MAY	2661	2526	2325	-200	-7.94	2325	-200	-7.94
	JUN	5689	5015	4757	-258	-5.15	4896	-119	-2.37
	JUL	2137	1743	1795	52	2.98	1745	2	0.11
	AUG	2075	1700	1705	4	0.26	1749	49	2.87
	SEPT	1311	1195	1219	24	2.00	1203	8	0.69
	OCT	1250	1183	1200	16	1.36	1184	1	0.08
	NOV	1103	1191	1195	4	0.33	1179	-12	-0.99
	DEC	961	1032	1036	4	0.43	1021	-11	-1.04
	JAN	965	1046	1052	5	0.51	1036	-10	-0.93
	FEB	930	1010	1021	11	1.10	1004	-6	-0.55
	MAR	988	837	849	13	1.52	834	-2	-0.29
1969	APR	1988	1772	1632	-140	-7.93	1744	-28	-1.59
	MAY	4063	3471	3378	-93	-2.67	3467	-4	-0.12
	JUN	4253	3128	3124	-4	-0.13	3124	-4	-0.13
	JUL	2879	2007	2076	69	3.42	2026	19	0.93
	AUG	1477	1394	1529	135	9.69	1480	86	6.16
	SEPT	1251	1214	1238	24	1.97	1222	8	0.68
	OCT	1425	1486	1501	15	0.98	1486	-0	-0.03
	NOV	1280	1287	1288	1	0.10	1273	-14	-1.11
	DEC	1066	1147	1149	2	0.16	1133	-13	-1.16
	JAN	960	1048	1050	3	0.26	1035	-12	-1.18
	FEB	1148	1139	1147	8	0.74	1130	-8	-0.73
	MAR	1221	1024	1036	12	1.16	1021	-3	-0.32
1970	APR	1653	1523	1527	4	0.24	1511	-12	-0.78
	MAY	8512	6926	6525	-401	-5.79	6745	-181	-2.61
	JUN	7643	5676	5640	-36	-0.63	5640	-36	-0.63
	JUL	3227	2846	2937	91	3.18	2998	152	5.34
	AUG	1833	1388	1449	62	4.43	1400	12	0.89
	SEPT	1598	1508	1523	16	1.04	1508	-0	-0.00
	OCT	1579	1531	1548	17	1.12	1533	2	0.13
	NOV	1352	1436	1441	6	0.40	1426	-10	-0.69
	DEC	1000	1061	1068	6	0.60	1052	-9	-0.83
	JAN	1034	1092	1099	7	0.67	1084	-8	-0.72
	FEB	1200	1172	1185	13	1.11	1168	-4	-0.32
	MAR	1469	1288	1301	13	1.02	1286	-2	-0.15
1971	APR	2684	2258	2133	-125	-5.54	2204	-55	-2.42
	MAY	5533	4452	4333	-120	-2.69	4445	-7	-0.16
	JUN	8216	7017	7010	-7	-0.10	7010	-7	-0.10
	JUL	4079	3043	3174	130	4.28	3130	87	2.84
	AUG	1755	1282	1289	7	0.52	1273	-8	-0.66
	SEPT	1572	1420	1436	16	1.10	1420	-0	-0.00

Table 2 (continued)

Muddy Creek Reservoir Analysis
-- Colorado River At Dotsero Gage --

		West Slope Demand				Metro Denver Lease			
Water Year	Month	Historic Dotsero Flows (cfs)	Simulated Base Flows (cfs)	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
1972	OCT	1209	1158	1175	17	1.46	1160	2	0.15
	NOV	1206	1263	1268	6	0.44	1253	-10	-0.80
	DEC	1133	1211	1217	6	0.51	1202	-9	-0.74
	JAN	1049	1130	1137	7	0.63	1122	-8	-0.71
	FEB	1074	1145	1158	13	1.13	1142	-4	-0.33
	MAR	1385	1200	1213	13	1.10	1198	-2	-0.16
	APR	1807	1493	1514	21	1.41	1499	6	0.37
	MAY	3721	2843	2666	-177	-6.22	2802	-41	-1.43
	JUN	5675	4393	4388	-4	-0.10	4388	-4	-0.10
	JUL	1958	1632	1700	68	4.15	1650	18	1.09
	AUG	1450	1343	1454	111	8.28	1405	62	4.62
	SEPT	1378	1339	1362	24	1.78	1347	8	0.61
1973	OCT	1371	1354	1369	15	1.08	1354	-0	-0.04
	NOV	1397	1433	1435	1	0.09	1419	-14	-1.00
	DEC	1066	1155	1157	2	0.16	1142	-13	-1.15
	JAN	1022	1101	1103	3	0.25	1088	-12	-1.12
	FEB	1015	1096	1104	8	0.77	1088	-8	-0.76
	MAR	1110	1040	1052	12	1.13	1036	-3	-0.33
	APR	1283	1208	1226	18	1.47	1210	2	0.18
	MAY	5164	4218	3870	-348	-8.25	4090	-128	-3.02
	JUN	6996	5806	5796	-9	-0.16	5796	-9	-0.16
	JUL	5108	4067	4068	1	0.03	4153	87	2.13
	AUG	2137	1780	1826	47	2.63	1777	-2	-0.14
	SEPT	1398	1247	1262	16	1.25	1247	-0	-0.00
1974	OCT	1396	1229	1246	17	1.39	1231	2	0.16
	NOV	1266	1208	1214	6	0.47	1198	-10	-0.82
	DEC	1132	1209	1215	6	0.51	1200	-9	-0.74
	JAN	1048	1144	1151	7	0.63	1136	-8	-0.70
	FEB	1078	1166	1179	13	1.11	1162	-4	-0.32
	MAR	1462	1307	1320	13	1.01	1305	-2	-0.15
	APR	2050	1823	1842	19	1.07	1827	4	0.21
	MAY	7889	6736	6513	-223	-3.31	6685	-51	-0.76
	JUN	6774	5372	5365	-7	-0.13	5365	-7	-0.13
	JUL	2879	2429	2468	39	1.61	2515	87	3.56
	AUG	1700	1273	1370	97	7.61	1320	48	3.74
	SEPT	1467	1092	1107	16	1.43	1093	1	0.12
1975	OCT	1312	1314	1330	16	1.20	1315	1	0.05
	NOV	1148	1276	1279	3	0.26	1264	-12	-0.96
	DEC	1035	1164	1169	4	0.35	1153	-11	-0.95
	JAN	1040	1170	1175	5	0.43	1160	-10	-0.86
	FEB	1110	1247	1257	11	0.87	1241	-6	-0.48
	MAR	1067	1036	1048	13	1.21	1033	-3	-0.25
	APR	1573	1284	1302	19	1.45	1286	3	0.22
	MAY	3527	2938	2642	-296	-10.06	2851	-87	-2.96
	JUN	6346	5620	5611	-8	-0.15	5611	-8	-0.15
	JUL	4518	3982	4010	27	0.69	4069	87	2.17
	AUG	1953	1573	1631	58	3.68	1581	9	0.55
	SEPT	1450	1255	1279	24	1.90	1263	8	0.66
1976	OCT	1351	1212	1228	16	1.33	1213	1	0.08
	NOV	1266	1379	1383	4	0.27	1367	-12	-0.87
	DEC	1050	1172	1176	4	0.36	1161	-11	-0.93
	JAN	1006	1128	1134	5	0.46	1118	-10	-0.88
	FEB	1141	1236	1247	11	0.90	1230	-6	-0.45
	MAR	1302	1044	1057	13	1.22	1042	-2	-0.23
	APR	1544	1377	1397	21	1.51	1382	5	0.38
	MAY	3547	3019	2764	-255	-8.46	2962	-57	-1.90
	JUN	3808	3263	3259	-4	-0.13	3259	-4	-0.13
	JUL	1859	1746	1827	81	4.63	1777	31	1.76
	AUG	1464	1466	1565	99	6.74	1516	50	3.39
	SEPT	1381	1196	1219	24	2.00	1204	8	0.69

Table 2 (continued)

Muddy Creek Reservoir Analysis
-- Colorado River At Dotsero Gage --

		West Slope Demand				Metro Denver Lease			
Water Year	Month	Historic Dotsero Flows (cfs)	Simulated Base Flows (cfs)	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
1977	OCT	1192	1205	1220	15	1.21	1205	-0	-0.04
	NOV	1003	1053	1055	1	0.13	1039	-14	-1.36
	DEC	854	908	910	2	0.20	895	-13	-1.47
	JAN	816	890	893	3	0.31	878	-12	-1.39
	FEB	786	770	785	15	1.96	768	-2	-0.21
	MAR	630	624	639	15	2.43	624	0	0.00
	APR	1123	1090	1112	22	2.02	1097	6	0.59
	MAY	1437	1473	1481	7	0.49	1481	7	0.49
	JUN	1631	1627	1630	3	0.20	1630	3	0.20
	JUL	1311	1360	1384	24	1.79	1369	9	0.68
	AUG	1371	1433	1465	32	2.21	1450	17	1.16
	SEPT	1232	1278	1311	33	2.62	1296	18	1.39
1978	OCT	960	1045	1070	25	2.43	1055	10	0.98
	NOV	677	719	747	28	3.88	731	12	1.71
	DEC	726	765	791	26	3.36	776	11	1.38
	JAN	758	722	745	23	3.22	730	8	1.12
	FEB	745	674	694	21	3.07	678	4	0.59
	MAR	810	795	812	17	2.15	797	2	0.25
	APR	1604	1525	1552	27	1.75	1536	11	0.73
	MAY	4178	3585	3178	-406	-11.33	3178	-406	-11.33
	JUN	7488	6901	6624	-277	-4.02	6515	-386	-5.59
	JUL	3075	2492	2517	25	1.01	2563	72	2.88
	AUG	1428	1416	1519	103	7.29	1448	32	2.29
	SEPT	1331	1243	1259	16	1.26	1243	-0	-0.01
1979	OCT	1216	1256	1272	15	1.23	1257	0	0.03
	NOV	1223	1222	1225	3	0.21	1209	-13	-1.07
	DEC	814	838	841	3	0.37	826	-12	-1.44
	JAN	755	788	792	4	0.52	777	-11	-1.40
	FEB	822	851	861	10	1.16	844	-7	-0.80
	MAR	906	925	937	12	1.32	922	-3	-0.32
	APR	1422	1527	1545	18	1.19	1529	3	0.16
	MAY	5412	4825	4532	-293	-6.07	4699	-126	-2.62
	JUN	7841	7019	7010	-9	-0.12	7010	-9	-0.12
	JUL	4415	3387	3445	58	1.72	3395	8	0.24
	AUG	1652	1541	1708	167	10.82	1659	118	7.63
	SEPT	1300	1101	1117	16	1.42	1106	5	0.44
1980	OCT	1249	1136	1145	8	0.73	1130	-7	-0.60
	NOV	1108	1171	1160	-11	-0.96	1144	-27	-2.30
	DEC	1081	1169	1158	-11	-0.92	1143	-26	-2.21
	JAN	1021	1122	1113	-10	-0.87	1098	-25	-2.22
	FEB	1026	1106	1102	-4	-0.37	1085	-21	-1.89
	MAR	1020	913	921	8	0.89	906	-7	-0.77
	APR	1645	1326	1339	13	0.98	1323	-3	-0.20
	MAY	5682	4429	4125	-304	-6.86	4341	-88	-2.00
	JUN	7134	5631	5616	-15	-0.27	5616	-15	-0.27
	JUL	2462	2228	2300	72	3.25	2250	22	1.00
	AUG	1433	1135	1209	74	6.50	1160	25	2.16
	SEPT	1341	1136	1159	24	2.10	1144	8	0.72
1981	OCT	1053	1099	1114	15	1.35	1099	-0	-0.03
	NOV	981	1048	1049	1	0.11	1033	-14	-1.38
	DEC	921	984	985	2	0.16	970	-14	-1.37
	JAN	753	873	875	3	0.30	860	-13	-1.43
	FEB	663	678	693	15	2.20	676	-2	-0.27
	MAR	668	656	671	15	2.30	656	-0	-0.00
	APR	1097	1191	1214	22	1.85	1198	6	0.54
	MAY	1735	1739	1640	-99	-5.68	1667	-72	-4.14
	JUN	2553	2566	2504	-62	-2.40	2565	-1	-0.04
	JUL	1352	1333	1411	79	5.91	1351	18	1.39
	AUG	1336	1415	1527	112	7.91	1424	9	0.63
	SEPT	1305	1225	1249	24	1.95	1234	8	0.67

Table 2 (continued)

Muddy Creek Reservoir Analysis
 -- Colorado River At Dotsero Gage --

Water Year	Month	West Slope Demand					Metro Denver Lease		
		Historic Dotsero Flows (cfs)	Simulated Base Flows (cfs)	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	1037	1003	1022	19	1.85	1007	3	0.34
	NOV	849	881	876	-4	-0.48	861	-20	-2.25
	DEC	726	791	786	-5	-0.64	770	-20	-2.55
	JAN	739	769	765	-4	-0.53	750	-19	-2.50
	FEB	741	762	764	2	0.21	747	-15	-1.98
	MAR	858	831	841	10	1.17	826	-5	-0.65
1982	APR	1257	1209	1229	19	1.61	1213	4	0.32
	MAY	3412	3148	2887	-261	-8.30	2887	-261	-8.30
	JUN	5833	5153	4930	-223	-4.33	4999	-154	-2.99
	JUL	3584	3239	3261	22	0.67	3304	64	1.99
	AUG	2056	1813	1911	98	5.43	1862	49	2.71
	SEPT	1551	1452	1425	-27	-1.89	1418	-34	-2.36

Metro Denver Lease Demand

Although intended to serve West Slope interests, water from a reservoir at Muddy Creek would be marketed to the Denver Water Board (Metro Denver Lease) in the short term (25 years). The short-term operational scenario was formalized under a December 1986 Denver Water Board-River District Agreement. Muddy Creek Reservoir would be operated to fulfill the four following primary demands under the Metro Denver Lease:

1. Supply one-half of the Green Mountain natural fill deficit during dry years (approximately 5 out of 30 years under present development conditions and as often as 12 years out of 30 with full development of East Slope storage) when Williams Fork Reservoir exceeds 65,000 acre-feet. This demand would come primarily in August and September, after the Bureau of Reclamation has determined that Green Mountain will not achieve its legal fill from the intervening inflow between Dillon and Green Mountain. This release would offset releases from Dillon Reservoir. The other 50 percent of the fill deficit would be supplied by Williams Fork Reservoir, as was done in 1977. When Williams Fork Reservoir is below 65,000 acre-feet, the entire Green Mountain fill deficit would be supplied (up to the terms of the lease). Under the terms of the River District-Denver Water Board lease, this demand could not exceed 30,000 acre-feet in any given year, or 45,000 acre-feet any 3 years.

2. Supply the water necessary to make up Green Mountain water operations shortages to permit full utilization of the 100,000 acre-foot pool (this demand is referred to as the 28,800 acre-foot sales level in supporting hydrology tables).

3. Provide for 2,000 acre-feet of water supply for Middle Park Water Conservancy District, as required by the Intergovernmental Agreement.

4. Provide for augmentation releases to bring the July and August flows out of Muddy Creek Reservoir up to 100 cfs enhancing flows in Muddy Creek and the Colorado River downstream. The availability of these releases would be dependent upon storage in the reservoir, but they could be used for a variety of enhancement purposes if such enhancement proves to be significant (e.g., recreation, aquatic habitat).

There are presently no Colorado Water Conservation Board instream flow requirements on Muddy Creek; however, Muddy Creek Reservoir operational analysis has assumed a 13 cfs minimum flow below the proposed dam.

West Slope Demand

The River District-Denver Water Board Lease has a term of 25 years. After the lease expires, the yield of Muddy Creek Reservoir could be used to meet West Slope water needs, could continue to be leased to Denver, or could be used for a combination of these needs. A scenario consisting primarily of oil shale demand provides the most reasonable projection of West Slope needs 25 years in the future. Muddy Creek Reservoir would be operated to fulfill the four following primary demands under a West Slope scenario:

1. Supply industrial oil shale demand downstream on the Colorado River. For operational analysis this demand was assumed to be a uniform 930 acre-feet per month demand over 10 months of the year (July through April). May and June are excepted since natural flows in these months would normally support the demand.

2. Supply the water necessary to make up Green Mountain water operation shortages to permit full utilization of the 100,000 acre-foot pool (this demand is also referred to as the 28,800 acre-foot sales level).

3. Provide for 2,000 acre-feet of water supply for Middle Park Water Conservancy District, as required by the Intergovernmental Agreement.

4. Provide for augmentation releases to bring the July and August flows out of Muddy Creek Reservoir up to 150 cfs, enhancing flows in Muddy Creek and the Colorado River downstream. The availability of these releases would be dependent upon storage in the reservoir, but they could be used for a variety of enhancement purposes if such enhancement promises to be significant (e.g., recreation, aquatic habitat).

As with the Metro Denver Lease scenario, a 13 cfs instream flow requirement on Muddy Creek below the dam was assumed.

Resource Management Plan

In the 1984 Kremmling Resource Management Plan Record of Decision, the BLM lists livestock grazing, wildlife habitat, and water quality management as the priority land uses for the Muddy Creek Reservoir area. The livestock grazing priority use area is committed to the production of livestock forage and the grazing of livestock. The wildlife and water priority zones include lands important to wildlife and lands committed to the protection of water quality. The area also includes lands in Visual Resource Management Class II, III and IV. Class II objectives are to retain the existing character of the landscape. Class III objectives are to partially retain the existing character of the landscape, while Class IV objectives provide for management activities which may result in major modification of the existing character of the landscape.

Selection of the Muddy Creek site would require an amendment to the Kremmling Management Plan to change approximately 1740 acres of livestock grazing, 30 acres of wildlife habitat, and 1.1 miles of water quality management priorities to the recreation management priority category to accommodate recreational use at the Muddy Creek Reservoir. The amendment would also change approximately 1,080 acres of Class II and 40 acres of Class III Visual Resource Management Class to Class IV. The management objectives for Class IV would be consistent with the construction of the project. The visual resource decision in the Kremmling Resource Management Plan would also be changed to establish consistency with the Bureau Manual. This would remove Visual Resource Management classes as priority management areas and establish objectives for Visual Resource Management as described in Bureau Handbook H-8410-1.

SPECIES DISCUSSIONS

Plants

Osterhout's Milkvetch

Osterhout's milkvetch (Astragalus osterhoutii M.E. Jones) was first collected approximately "4 miles below Sulphur Springs, Grand County, Colorado" by George Osterhout in 1905 (Peterson et al. 1981). The species was first described by Marcus Jones in 1923 (Jones 1923). The status of Osterhout's milkvetch has been reviewed at least twice in the past for listing as Endangered, in 1975 and 1976 (Federal Register 1975, Federal Register 1976) but was denied a listed status as Endangered during both reviews. The species has recently been proposed for federal listing as endangered (Federal Register 1988).

Osterhout's milkvetch is a member of the Fabaceae family and the Astragalus genus, of which there are 531 species within North America. Astragalus osterhoutii is a tall (50 to 100 cm) rush-like perennial plant, with numerous stems branching from a common woody caudex. The leaves are linear and pinnate consisting of 9 to 13 leaflets 1.5 to 3.0 cm long. Numerous white to cream flowers 18 to 20 mm long are borne on a raceme. The linear pods are 2.5 to 4.0 cm long and 3 to 4 mm in diameter, contain numerous seeds, are dorsally compressed with a rhombic to elliptical cross section, and are pendulous with stipes 2 to 6.5 mm long (Harrington 1964).

Life History and Distribution

Osterhout's milkvetch is a perennial plant that dies back to the woody caudex each winter. Depending on the particular year, the species generally initiates spring growth in mid to late April. The plant grows vegetatively through mid to late June. Flowering commences in late June to early July. According to Karron (1987), pollination primarily occurs through visitation by bumblebees and bees. Fruits (seed pods) develop soon after flowering and mature through July. In early August, most fruits are fully mature and begin to open. Seeds detach from the parent plants by desiccation and gravity. Although not documented in the literature, the seeds likely germinate in early to mid spring in response to increased temperatures and available moisture.

Astragalus osterhoutii inhabits seleniferous, clayey soils derived primarily from the Niobrara Shale and the Pierre Shale. Within these geologic formations, the plant may occur on a variety of topographic positions and landforms between 7,500 and 7,700 feet elevation. However, the species predominantly grows on relatively flat areas and barren knolls (Peterson et al. 1981 and Grah and Neese 1986). The species has been observed to grow on denuded clay hills, in gulches, at the foot of gullied bluffs, and in disturbed areas such as along roads and at granular borrow sites. The species has also been observed to grow on the Troublesome Formation, however, not as vigorously as on the Niobrara Shale or the Pierre Shale.

The vegetal cover component of the exploited habitat primarily involves grassy inclusions with a relatively sparse cover of shrubs within sagebrush

communities (Grah and Neese 1986). Principal associated species include western wheatgrass (Agropyron smithii), Indian ricegrass (Oryzopsis hymenoides), blue grama (Bouteloua gracilis), bottlebrush squirreltail (Sitanion hystrix), shortstem buckwheat (Eriogonum brevicaulis), Hoods phlox (Phlox hoodii), broom snakeweed (Gutierrezia sarothrae), mat penstemon (Penstemon caespitosus), Wyoming big sagebrush (Artemisia tridentata wyomingensis), fringed sage (Artemisia frigida), little rabbitbrush (Chrysothamnus viscidiflorus), and gray horsebrush (Tetrademia canescens) (Grah and Neese 1986).

Osterhout's milkvetch is only known to occur in Grand County, Colorado, within the upper Colorado River drainage area. Astragalus osterhoutii is only known to occur in the Muddy Creek and Troublesome Creek drainages of Middle Park north and northeast of Kremmling, respectively. The Troublesome Creek populations were identified only within the last 1 to 2 years (Karron 1987, O'Kane 1987, Anderson 1987). These populations occur approximately 8 miles to the east and out of the study area, which is confined to the Muddy Creek drainage.

Within the study area, the species is predominantly confined to the tablelands and terraces within the Niobrara Shale on the west side of Muddy Creek. Figure 5 shows the location of Osterhout's milkvetch populations within the vicinity of the reservoir site. A relatively small population was identified on the east side of Muddy Creek in a small area of outcropping Niobrara Shale (Grah and Neese 1986). These populations constitute the majority of the known populations in the Muddy Creek drainage. Additional populations were identified within the Red Dirt Creek drainage (a tributary to Muddy Creek) approximately 4 miles west of Muddy Creek as well as one population recently discovered by Karren and reported by O'Kane (1987) located approximately 1 mile northeast of Kremmling near the municipal refuse dump.

Based on observations made in July, 1987, on the various populations shown in Figure 5, densities of Osterhout's milkvetch plants vary from a low of approximately 200 individual plants per acre to a high of approximately 4,000 plants per acre. An estimated 50,000 plants occur within the vicinity of the proposed Muddy Creek Reservoir, most of which occur in the population concentration areas mapped on Figure 5, although individuals occur across all of the area having exploitable habitat.

Observations made on Astragalus osterhoutii during the summers of 1985, 1986, and 1987 indicated that individuals of the plant are locally abundant, robust, and healthy; of all size and age classes; and are reproducing and setting and dispersing seeds successfully. According to Peterson et al. (1981), numbers of individuals and densities of individuals fluctuate from year to year, making a definitive assessment of population trends difficult. The species is lightly browsed either by livestock or wildlife, or both, without detriment to the species. There appears to be some tolerance or even preference for light soil disturbance as evidenced by the species' occurrence on road cuts and fills in the area (Grah and Neese 1986, Peterson et al. 1981).

FIGURE 5

VEGETATION FEATURES INUNDATED
BY THE PROPOSED MUDDY CREEK
RESERVOIR

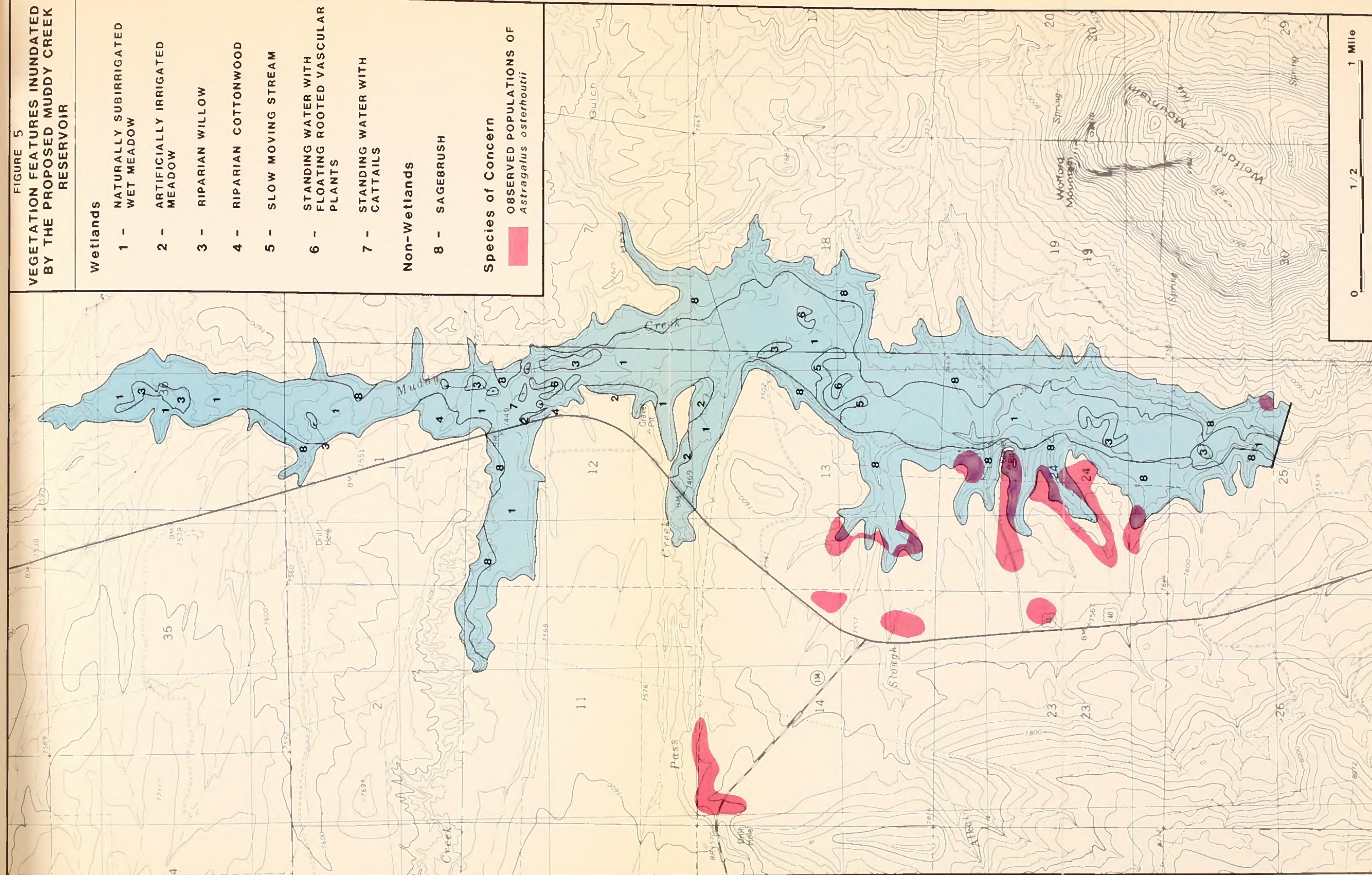
Wetlands

- 1 - NATURALLY SUBIRRIGATED WET MEADOW
 - 2 - ARTIFICIALLY IRRIGATED MEADOW
 - 3 - RIPARIAN WILLOW
 - 4 - RIPARIAN COTTONWOOD
 - 5 - SLOW MOVING STREAM
 - 6 - STANDING WATER WITH FLOATING ROOTED VASCULAR PLANTS
 - 7 - STANDING WATER WITH CATTAILS
- Non-Wetlands
- 8 - SAGEBRUSH

Species of Concern



OBSERVED POPULATIONS OF
Astragalus osterhoutii



0 1/2 1 Mile

Effects on the Species

Any adverse impact to Astragalus osterhoutii would be considered significant; however, the magnitude of adverse impacts would depend on the degree or success of application of measures to conserve or protect the species. Osterhout's milkvetch could be directly impacted as a result of project construction and operation. Direct impacts could result from inundation due to the ponded water behind the dam; perennial soil saturation in response to a rise in the water table induced by the ponded water; or by construction activities associated with the project facilities such as road construction, borrow area development, dam construction, transmission line tower relocation, or recreation site development. Indirect impacts could occur through increased use of the area adjacent to the reservoir shoreline due to trampling by humans and vehicles as well as through land clearing associated with increased recreational use.

The principal direct impact to the species would involve inundation. To determine the extent and magnitude of this potential impact, the reservoir shoreline (7490 feet) was level surveyed and staked in the vicinity of known populations and habitat of Osterhout's milkvetch in June 1987. The area was then surveyed for occurrence of milkvetch within the inundated zone. As discussed previously, the populations of the species primarily occur on the flat terraces above the Muddy Creek drainage. Individuals of the milkvetch also occur topographically below the terrace populations where suitable soils and seed have washed down into gullies and erosional surfaces. Based on the survey conducted in 1987, the majority of Osterhout's milkvetch individuals that would be inundated occur below the terrace populations. Approximately 1,550 plants would be inundated, of which 800 to 900 occur in approximately 5 acres of good habitat as defined by areas with fairly dense populations. In addition, approximately 13 acres of marginal habitat in gullies and erosional surfaces below the terraces would also be inundated, accounting for the remaining 650 to 750 plants. The exception is a small population (200 plants) located on the east side of the reservoir. The cumulative area containing the species that would be inundated would be approximately 18 acres. The loss of 1,550 individual plants would represent an estimated 2 to 3 percent of the total number of individuals in the vicinity of the proposed Muddy Creek Reservoir.

Approximately 132 acres of habitat containing populations of the milkvetch were delineated in the vicinity of the reservoir in a survey in 1985 (Grah and Neese 1986). During the June 1987 survey, the extent of the populations approached approximately 160 acres. Considerably more individual plants were observed during 1987 also. These observations illustrate the previously mentioned variation that occurs in the population of the plant from year to year. This variation makes absolute quantitative determination of impacts to the species difficult.

Populations occur on both BLM-administered and private land, with most of the occupied habitat on BLM-administered land. Most of the individuals noted in 1987 that would be inundated were located on private land. This indicates that the major population centers, and probably the best habitat for the species, are above the area of inundation and on BLM-administered land. During

flood periods when the reservoir would rise 8 to 10 feet, additional plants would be inundated. Inundation at flood stage would be short term (1 to 3 days) and would not affect the species except at the shoreline where wave action could erode soil and dislodge plants.

In addition to loss of habitat and individuals of the species due to inundation, the species could be impacted by perennial soil saturation in response to a rise in the water table induced by filling the reservoir. The magnitude and extent of this potential impact is not known; however, it is thought to be small due to the probable steep gradient of the water table surface and the unlikely "mounding" of the water table along the margins of the reservoir.

As previously stated, indirect impacts to the species could include destruction of habitat and individuals resulting from recreation development and increased use of the area adjacent to the reservoir shoreline. Trampling by humans and vehicles, as well as land clearing could accompany the development and increased use. The impact of trampling is a major concern and poses the greatest threat to the species in the vicinity of the reservoir. However, all recreation development and use will be restricted to areas away from habitat and populations of the plant on BLM-administered and River District lands which totally surround the reservoir. Therefore, it is unlikely that the plant would be indirectly impacted due to recreational use of the reservoir.

Grazing and road construction in the project area have cumulatively impacted this species. Herbivory by cattle and wildlife has been relatively light, and as previously mentioned, the plant's exploitation of road cut and fill shoulders suggests its tolerance or preference for light soil disturbance. Impacts due to previous grazing and road construction, therefore, have not been noticeably detrimental. With appropriate mitigation such as that presented below, development of the proposed Muddy Creek Reservoir would not directly add significantly to cumulative impacts to the plant. The attraction of a reservoir, however, would undoubtedly spur an indeterminate amount of private development within the range of the plant, although such development would not occur on BLM-administered lands or River District lands around the reservoir. Therefore, direct and indirect cumulative impacts would occur due to implementation of this project.

In summary, the proposed Muddy Creek Reservoir may effect Osterhout's milkvetch directly, indirectly, and cumulatively; however, implementation of appropriate mitigation as discussed below would reduce these impacts.

Proposed Actions and Measures to Minimize Impacts

Inundation both of suitable habitat and individual plants would occur due to construction and operation of the proposed Muddy Creek Reservoir. Reducing the level of the reservoir would reduce the amount of habitat and number of individuals to be inundated but would make the project infeasible. Diking was also investigated during an early stage of impact assessment, but was determined infeasible due to potential problems with ponded water and high cost. Most of the habitat that would be inundated occurs in draws and appears to be the result of deposition of soils eroded from the tops of the benches, which

are the main population centers of the plant. Therefore, the areas to be inundated consist of marginal habitat in comparison to the main population centers; however, these areas can produce fairly large numbers of the species. The plant also colonizes disturbed areas such as road cuts and fills and a material site. These observations suggest that the populations of the plant could probably be enhanced and potential impacts of the project fully offset through transplanting and vegetation manipulation.

The impact of the proposed Muddy Creek Reservoir could be mitigated through clearance surveys at all project construction and/or disturbance sites just prior to implementation and through the development of a Conservation Plan for the species. The plan would be developed in conjunction with the Bureau of Land Management, Fish and Wildlife Service, Colorado Natural Areas Program, and the River District. The goal of the plan would be to enhance the habitat of the species to the point that impacts at Muddy Creek would be fully mitigated. The plan should be designed to learn more about the biology and habitat needs of the plant as well as to investigate the feasibility of successfully establishing plants at new sites in the vicinity of the reservoir and perhaps expanding the numbers of individuals and extent of populations to offset the direct impact to the plant due to inundation. One of the implicit rationales for conducting such studies is based on the inherent uncertainty in assessing impacts to the plant. Relatively little is known about the biology and habitat requirements of the plant, and therefore it is difficult to identify impacts and mitigation with great precision. The plan would encompass studies and management activities for a period of five years and would cost approximately \$50,000.

To promote mitigation success, a series of ministudies should be performed to provide the necessary data.

Ministudy I: During the course of preparing the Rock Creek/Muddy Creek EIS, the size of the plant populations and density of individuals within each population have been observed to vary from year to year. No quantitative measurements have been taken to date to document this observation; therefore, populations of the plant in the vicinity of the reservoir should be monitored, measured, and mapped on an annual basis for the duration of the five-year study and less frequently (i.e., 2 to 3 year intervals) for the duration of the project. The density of plants in each monitored population should be quantitatively measured. Permanently located plots should be established to facilitate the monitoring

Ministudy II: This ministudy should be implemented to characterize the edaphic nature of the plant's habitat. The species of concern is a narrow endemic, restricted to a very specific substrate or substrates. The hypothesized substrate has never been characterized in detail. Therefore, at least 20 soil samples should be obtained from occupied habitat and analyzed for various chemical and physical parameters that may have correlation to the occurrence and distribution of the plant in the reservoir area.

Ministudy III: The vegetative characteristics of the plant's habitat are not known in detail. Transects should be located within plant populations along which quantitative measurements should be conducted to determine the horizontal

and vertical structure of the community. In addition, a comprehensive species list should be compiled for each transect.

Ministudy IV: Extensive surveys for individuals and habitat of the species should be conducted in the Muddy and Troublesome Creek drainages. More detailed information on the distribution and frequency of individuals and habitat in the geographic area could assist in more clearly determining the cumulative impacts on the plant due to direct and indirect impacts as well as facilitate management of the plant on federally administered public lands.

Ministudy V: It has been hypothesized that livestock grazing, including trampling as well as herbivory, has effected the plant in the vicinity of the reservoir, though it is uncertain as to whether these effects are beneficial or detrimental to the plant. Information to this effect should be obtained by constructing exclosures within several populations where grazing is anticipated to occur over the course of the five-year study. The exclosures would preclude cattle from trampling or browsing on the plant. Exclosures should include reinforced wire fencing of sufficient strength and durability to preclude cattle from the exclosure for the duration of the five-year study. Quantitative measurements in terms of number of plants, condition of plants, plant phenology, and density, condition, and species composition of surrounding vegetation should be made on an annual basis both inside the exclosure as well as immediately outside the exclosure for comparison purposes. The Troublesome Creek population could be used as a control to compare the grazing study results with.

Ministudy VI: Prior to implementing actual mitigation efforts, a ministudy should be implemented to determine the success of vegetative manipulation and transplantation of seeds or adult specimens into new habitat. This ministudy should entail clearing, with a crawler tractor, two or more plots one to two acres in size of sagebrush scrub adjacent to existing populations but not containing plants. In one of these plots, adult plants from the inundation zone as well as seed from the plant would be planted in the disturbed site to determine the feasibility of establishing plants in areas not already occupied. The other cleared plot would be left as a control to compare to the planted plot as well as to determine whether the plant will pioneer the disturbed site. One of the objectives of the ministudy should be to determine if the plant is a pioneer or an early seral species thereby depending on or preferring disturbed sites. Further, it has been hypothesized that heavy grazing pressure in the sagebrush complex around the reservoir site may have allowed sagebrush to increase in dominance, thus affecting this sensitive species, as it has been observed to prefer open areas within sagebrush complex but rarely occurs in dense sagebrush stands. Such a ministudy would likely provide data and specific observations that may help to prove or nullify this hypothesis. The cleared plots should be fenced as discussed above and monitored annually with appropriate quantitative measurements taken to determine success.

Ministudy VII: As an extension of and a control for the previous ministudy in which plants and seed will be planted into a cleared plot in areas where the species already occurs, adult plants and seeds should be

planted into areas of sagebrush complex not containing the species of concern. The transplanted seed and plants should be monitored annually during the five-year study.

In addition to direct transplants of adults and seeds to new areas in order to mitigate direct losses caused by inundation, areas around the shoreline containing the species would be secured from trampling through judicious construction of fences. To this end, approximately 4.5 miles of fencing would be required. Recreation, recreationists, and recreation site development as well as grazing would be prohibited on land adjacent to the reservoir in areas containing the species that will be purchased by the River District. Recreational use on BLM-administered land will be strictly supervised to likewise protect this plant from inadvertent trampling or displacement.

In addition, if the species was listed as threatened or endangered by the FWS, one of the populations on private land west of Highway 40 in the Pass Creek or Red Dirt Creek drainages would be protected by fee purchase, conservation easement, and/or transfer to the BLM. The easement would include measures deemed necessary by the BLM after review and discussion with the FWS. Based on preliminary investigation, the total cost for the easement, including administration and management, would be approximately \$25,000.

Implementation of the above measures would greatly reduce the magnitude of total impact to Astragalus osterhoutii as well as increase the likelihood of successful mitigation. Securing the populations along the west shore of the reservoir through fencing would reduce the potential for significant indirect impacts due to trampling by humans, livestock, or vehicles. Minimizing recreation development in the vicinity of the milkvetch populations would further reduce the magnitude of total impact to the species as a result of project implementation.

The proposed measures would alleviate and reduce significant impacts to this plant, and therefore, the proposed project would have minimal effect on the plant.

Fish

Colorado Squawfish

Life History and Distribution

The Colorado squawfish is presently found only in the Colorado River system above Glen Canyon Dam (Lake Powell). It was once found throughout the entire basin in all main channels and larger tributaries, but it has become extinct below Glen Canyon Dam and in the Green River above Flaming Gorge Dam. Recent attempts have been made to reintroduce the species into the Gila River system of Arizona. In the upper Colorado River, the squawfish is found from Lake Powell upstream to near the Government Highline Dam near Palisades, Colorado (Figure 6), which is an effective barrier to upstream fish migration (Valdez et al. 1982). It is probable that the species' earlier distribution included the river at least to De Beque and probably upstream to Rifle. Sampling above the Government Highline Dam has been sporadic and not nearly as intensive as studies below this barrier. Therefore, there is a slight chance that a few adult squawfish still exist in the De Beque area, but that none have been collected. Adult squawfish are also found in the lower Gunnison River, a tributary of the Colorado River near Grand Junction.

Adult Colorado squawfish are generally rare in the Colorado River, but can be locally abundant in certain habitats at certain times of the year (Valdez et al. 1982). Adults are principally found in the upper Colorado River near Grand Junction. Juvenile squawfish are principally found below Moab, Utah, on the lower portion of the Colorado River and are also quite uncommon, although 20 to 30 young-of-the-year (YOY) are at times found in one habitat (Valdez et al. 1982). Larval squawfish have been found in both the upper (Grand Junction area) and the lower (Moab area) portions of the Colorado River. Adult squawfish utilize a variety of habitats, especially deeper runs along shorelines year-round and large backwaters during runoff (Holden and Wick 1982). They are often concentrated in flooded gravel pits near Grand Junction during runoff. Smaller juveniles and YOY prefer backwater habitat with a silt or sand bottom.

A suspected spawning site was located in 1982 near Clifton, just upstream from Grand Junction (Miller et al. 1983). This site was found through tracking of radio-tagged adults and collection of adults in spawning condition. A larval squawfish was also found in the area. Radio-tagged squawfish in 1983 did not home into the 1982 suspected spawning site, but showed behavior that may have indicated spawning in several sites (Miller et al. 1984). Based on collection of larval squawfish, the most probable site of spawning was near Black Rocks, a deep canyon area downstream from Grand Junction (Miller et al. 1984) (Figure 6), although larval squawfish were again found in the upstream areas near the confluence of the Gunnison River (Archer et al. 1984). Therefore, several spawning sites between Black Rocks and Clifton may exist, as well as others below Black Rocks.

In recent years, considerable attention has been focused on the section of river between the Government Highline Dam and the mouth of the Gunnison

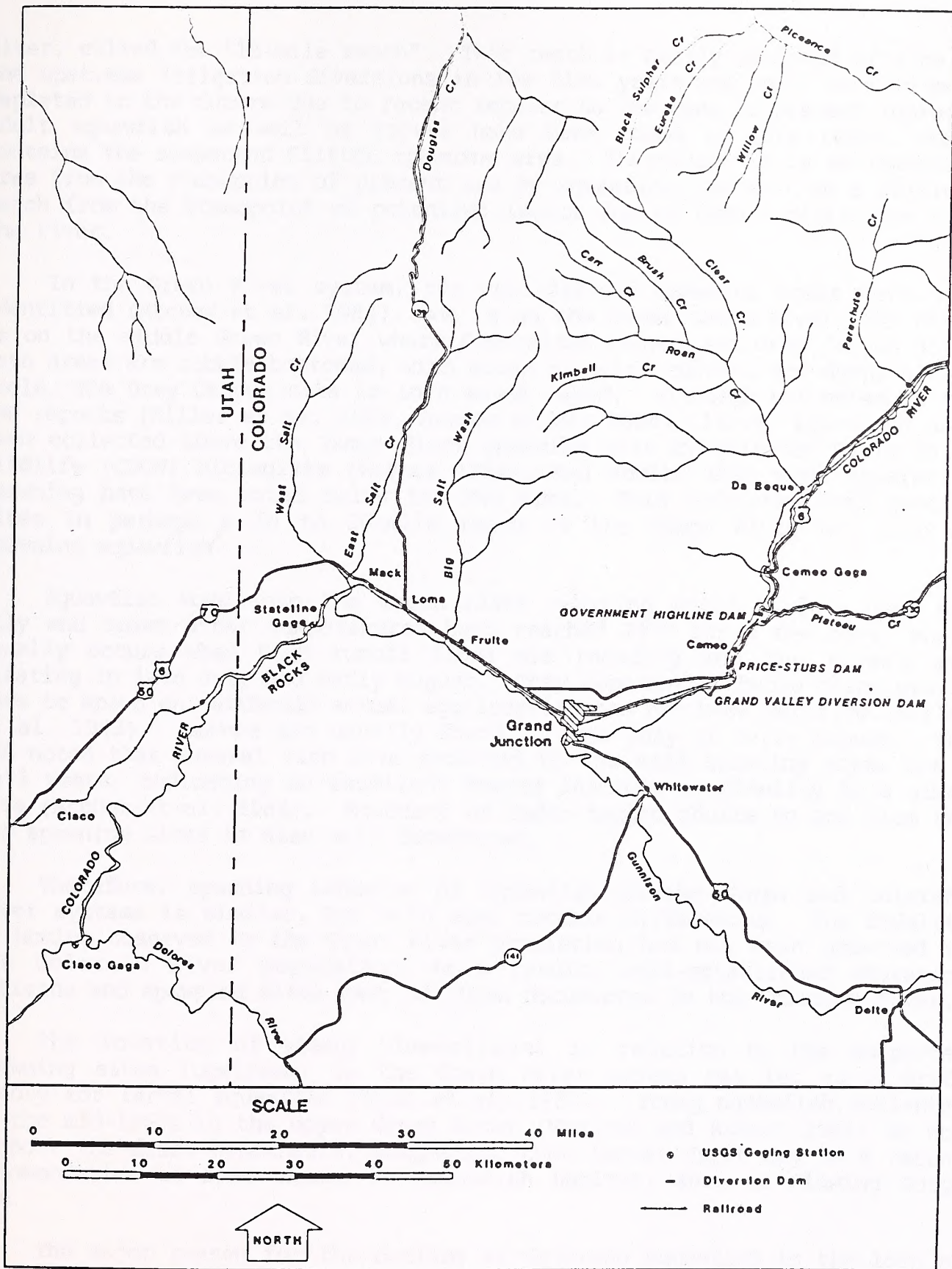


Figure 6

Colorado River near Grand Junction, Colorado

River, called the "15-mile reach". This reach is nearly depleted of flow by the upstream irrigation diversions in low flow years and will be even more depleted in the future due to recent repairs to the dams to prevent leakage. Adult squawfish as well as larvae have been found in this reach, which contains the suspected Clifton spawning area. Therefore, it is an important area from the standpoint of present use by squawfish, as well as a critical reach from the standpoint of potential impact due to future diversions from the river.

In the Green River system, two well-defined spawning areas have been identified (Archer et al. 1984). One is on the lower Yampa River; the other is on the middle Green River where Desolation Canyon and Grey Canyon join. Both areas are cobble bottomed, with areas of swift current and deep, slower pools. The Grey Canyon site is in a major rapid. Although not noted in the FWS reports (Miller et al. 1984, Archer et al. 1984), larval squawfish have been collected above the Yampa River spawning site by Colorado Division of Wildlife (CDOW) biologists (Haynes 1984), and adults that were apparently spawning have been noted below the FWS site. This indicates that several sites in perhaps a 10 to 20-mile reach of the Yampa River are used by spawning squawfish.

Squawfish move into the Green River spawning areas in late June and July and spawn after temperatures have reached 20°C for a few days, which usually occurs when high runoff flows are receding and the rivers are clearing in late July and early August. They apparently choose clean gravel bars to spawn on, although actual egg location has not been verified (Miller et al. 1983). Larvae are usually found in late July or early August. The FWS noted that several fish have returned to the same spawning areas for 2 to 3 years, indicating an excellent homing instinct or fidelity to a given site (Archer et al. 1984). Movement of radio-tagged adults to and from the two spawning sites is also well documented.

Therefore, spawning behavior of squawfish in the Green and Colorado river systems is similar, but with some notable differences. The fidelity or homing observed in the Green River population has not been observed in the Colorado River population. As a result, well-established migration patterns and spawning sites have not been documented in the Colorado River.

The location of young (downstream) in relation to the suspected spawning sites (upstream) in the Green River system has led to a drift theory for larval squawfish (Tyus et al. 1982). Young squawfish collected in the mid-1960s in the upper Green River (Vanicek and Kramer 1969) do not support the drift hypothesis, suggesting that larval drift may be a recent accommodation to some change in squawfish habitat, such as Flaming Gorge Dam.

The major reason for the decline of Colorado squawfish is the loss of habitat due to construction and operation of dams prior to 1965. Colorado squawfish cannot survive in reservoirs and also avoid cold, clear tailwaters (Holden and Wick 1982). These factors totally eliminated squawfish from the lower Colorado River Basin. In the upper basin, Colorado River Storage Project dams eliminated habitat in the main Colorado River in Glen Canyon

and in the upper Green River due to Flaming Gorge Dam. Habitat was also lost on the San Juan River due to Navajo Dam, and perhaps on the Gunnison River due to the Aspinall Unit dams. Reasons for decline of squawfish in free flowing portions that were not affected by temperature or direct habitat alteration, such as the Colorado River above Glen Canyon (Lake Powell), are less clear. In the Colorado River, squawfish were apparently more common before the major dams were completed on the Gunnison River in the early 1960s than at present (Holden 1979, Kidd 1977). Holden (1979) suggested that altered flows from these dams were the major factor affecting squawfish by causing poorer reproductive success, and similar conclusions have been drawn for the Green River below Flaming Gorge Dam (Holden 1980).

The actual mechanism involved with altered flows in lowering reproductive success is not known. A number of potential factors have been suggested, including competition with or predation by non-native fishes, disease and parasites, loss of spawning habitat, loss of young-rearing habitat, and changes in water quality (Seethaler 1978). It is highly possible that all or several of these mechanisms have reduced Colorado squawfish reproductive success since flows are variable; therefore, different factors may operate in different years. Little pre-1960 data are available to compare with the post-1960 information. Available data suggest that the major factors for decline in the Colorado River are the loss of, or changes in, habitat availability for young fish and the increased presence of non-native predators (Holden 1979). Backwaters, preferred young squawfish habitat, are very rare except below Moab, Utah, on the Colorado River and spawning habitat may also be limiting. Non-native fishes have become abundant in flooded gravel pits near Grand Junction, which provide constant pond-type habitat not found in the natural river systems. These ponds are more constant now that flows have become less variable and high flows have become reduced; therefore, they are more suitable for the non-native species. This increase in non-native fish and simultaneous decline in preferred squawfish habitat is probably the major mechanism affecting squawfish in the Colorado River today. Other researchers have suggested that competition or predation by introduced fish was the major factor in the decline of squawfish (Behnke and Nugent 1983), but it appears that these interactions with introduced species are primarily important in marginal habitat caused by depleted flows (Holden 1979, Holden and Wick 1982) and that they occurred only after squawfish populations had probably already been substantially reduced.

Holden (1980) compared yearly flow hydrographs for the Green and Yampa rivers with success of Colorado squawfish reproduction measured by the number of YOY found. It was shown that during a very low flow year (1977) reproductive success was extremely poor. Haynes (1984) sampled larval squawfish spawning sites for several years. In 1983, a very high flow year, his catch of larval squawfish in the Yampa River increased nearly thirty-fold over 1982. Similar collections in the Colorado River near Grand Junction were also made, but no dramatic increase in larvae were seen. The FWS (Archer et al. 1984) collected more YOY squawfish in the Colorado River in 1983 than in previous years and also found more near Grand Junction, where the species had seldom been collected previously. However, a more

efficient collection method used by the FWS in 1983 might account for the difference.

Available data support the hypothesis that Colorado squawfish reproductive success may suffer in areas and years of low flow. Additionally, the Colorado River has been more depleted than the Green River, and depletions were initiated earlier in this century (Joseph et al. 1977). Reproductive success of squawfish is lower in the Colorado River than in the Green River under essentially similar habitat conditions (Holden 1979, Miller et al. 1984, Archer et al. 1984). This would further suggest there is a link between depletion of flows and lowered squawfish reproductive success.

Effects on the Species

The Muddy Creek project would be too far upstream to impact the Colorado squawfish directly during construction. The major potential impact would occur with flow changes, especially changes that would reduce present flows in the 15-mile reach. It is during late summer (July, August, and September) that the potential for dewatering is greatest since normal river flows subside and irrigation demand is often greatest at this time. It is also during these months that spawning occurs and nursery areas for young are important.

Table 2 illustrates the types of flow reductions that would be expected in the 15-mile reach due to the Muddy Creek project. This table shows changes at Dotsero, which would be of the same magnitude as at Cameo, although the percentage at Cameo would be smaller due to a larger base flow. Flows would be augmented during late summer in many years, and flows would also be depleted in many years. The project would have only 2 years in the 21-year period of record (1962-1982) with depletions during late summer. All other years show augmentation of flows at that time. During most years, the project would benefit the Colorado squawfish during late summer by increasing flows in the 15-mile reach. Depletion during late summer would occur only 2 of the 21 years. For these depletion years, depletions would only occur in two of the three months of late summer, with augmentations occurring the other month (Table 2). The depletions are very small, 8 cfs in August of 1971 and 2 cfs in August of 1973.

The magnitude of the depletions, as well as the augmentations, would be relatively small, generally less than 10 cfs (Table 2). A peak augmentation of 118 cfs would occur in August 1979.

Depletions at other times of the year may also impact squawfish. During spring high flows, adult squawfish utilize backwaters that are formed at the mouths of washes and other points along the rivers. These habitats would not be available under lower flow regimes. Lower flows may also alter river temperatures, which in turn may effect cues for sex product maturation or other important life history functions. Most of the major depletions would occur during spring runoff when the reservoir is filling. Depletions of 100 cfs and more are common during May, with the peak May depletion being 406 in 1978.

Therefore, the project could negatively impact the Colorado squawfish in the 15-mile reach, as well as in other areas. However, the magnitude of these impacts alone would probably be small and difficult to quantify. The major concern over depletions caused by the project would be the cumulative impact of the depletions with those of other water development projects in the upper Colorado Basin.

The Bureau of Reclamation has several projects under construction or in the planning stages, including Dolores, Dallas Creek, Green Mountain II, and Ruedi Dam II. Private developments include Ridges subdivision, Homestake II, Battlement Mesa, Windy Gap, Denver Water Board, and others. Oil shale projects include Getty, Conoco, Chevron, Cities, Pacific, Union, Mobile, and others.

Table 3 shows the potential cumulative depletion due to the projects planned for the Colorado River at the Cameo and Cisco gauges. These depletions were obtained from the Metropolitan Denver Water Supply EIS cumulative depletions analysis. The greatest depletion percentages would occur in June, July, December, and January when 15 percent or more of the present flows would be depleted at the Cameo gauge. Downstream at the Cisco gauge, depletions of 12 to 13 percent would occur in April, June, and July.

The Cisco USGS gauge just across the Colorado border in Utah reflects the flow of most areas used by the Colorado squawfish since it is located within the area used most heavily by this species. Actual year-to-year variation in depletions would be expected to show even greater percentage depletion in below-average flow years. The level of depletion shown in Table 3 would be a significant reduction in flow and would continue the trend that has caused the present concern for this species. It is not known exactly how lowered flows affect Colorado squawfish, but this cumulative depletion would increase the negative aspects of this phenomenon. Therefore, even though the Muddy Creek project is relatively small in relation to many other depletions, it still contributes to the cumulative impact and, therefore, may affect the Colorado squawfish.

The cumulative depletion of these Colorado River projects may also alter temperature and sediment transport mechanisms, especially during low-flow periods, because rather large portions of the flow may be depleted.

Humpback Chub

Life History and Distribution

The humpback chub is found in several canyon areas of the upper Colorado Basin and in the Grand Canyon, in and near the mouth of the Little Colorado River. In the Colorado River between Grand Junction and Moab, it is found in Westwater Canyon and a portion of Ruby Canyon called Black Rocks (Figure 6). These habitats differ from the rest of the river by having areas up to 60 feet deep, apparently a necessary element of good adult humpback chub habitat. Present distribution appears to be similar to past distribution, with the exception of the Grand Canyon population, which has been greatly reduced due to the cold tailwaters of Glen Canyon Dam and also

Table 3

Present and Future flows in the Colorado River at Cameo and Cisco based on projected cumulative water development projects.

Colorado River
(Near Cameo)

Month	Baseline	Two Forks		Williams Fork Gravity		Cumulative	
	Flow	Incremental		Incremental		Flow Change	
	c.f.s.	c.f.s.	percent	c.f.s.	percent	c.f.s.	percent
<u>28-Year Average</u>							
Jan	1,640	0	0	0	0	-261	-15
Feb	1,575	0	0	0	0	-232	-14
Mar	1,673	0	0	0	0	-215	-12
Apr	2,660	0	0	0	0	-206	-7
May	6,987	-72	-1	-7	0	-137	-2
Jun	11,013	-637	-6	-116	-1	-1,752	-15
Jul	5,327	-292	-6	-24	0	-881	-16
Aug	2,484	0	0	0	0	-180	-7
Sep	2,012	0	0	0	0	-152	-7
Oct	1,990	0	0	0	0	-148	-7
Nov	1,953	0	0	0	0	-225	-11
Dec	1,753	0	0	0	0	-272	-15
Ann Avg	3,422	-83	-2	-12	0	-388	-11

Colorado River
(Near Cisco, Utah)

Month	Baseline	Two Forks		Williams Fork Gravity		Cumulative	
	Flow	Incremental		Incremental		Flow Change	
	c.f.s.	c.f.s.	percent	c.f.s.	percent	c.f.s.	percent
<u>28-Year Average</u>							
Jan	4,042	0	0	0	0	-292	-7
Feb	4,057	0	0	0	0	-272	-6
Mar	4,299	0	0	0	0	-360	-8
Apr	6,508	0	0	0	0	-781	-12
May	12,882	-72	-1	-7	0	-938	-7
Jun	16,246	-637	-4	-116	-1	-2,158	-13
Jul	7,304	-292	-4	-24	0	-917	-12
Aug	3,399	0	0	0	0	-178	-5
Sep	3,328	0	0	0	0	-71	-2
Oct	3,963	0	0	0	0	-116	-2
Nov	4,282	0	0	0	0	-229	-5
Dec	4,115	0	0	0	0	-307	-7
Ann Avg	6,202	-83	-1	-12	0	-552	-9

Source: Corps of Engineers, 1986.

a population in the upper Green River, which was eliminated by Flaming Gorge Dam.

In the Colorado River, humpback chub are locally abundant in Westwater Canyon and Black Rocks, and young and juveniles are present. An occasional adult has been found outside these preferred areas. Adult humpback chub prefer deep, swift runs and eddies with a rocky substrate (Valdez and Clemmer 1982). Young chub prefer backwaters or other available slack water habitats near the deep, swift runs. Adults apparently remain fairly stationary in these favored habitats, with few movements or migrations to other areas.

Little is known concerning the spawning of humpback chub. In 1980 and 1981, spawning occurred at temperatures of about 16°C during spring runoff in May and June in Black Rocks (Valdez and Clemmer 1982). Spawning probably occurs over gravel-cobble bars associated with the favored deep-canyon habitats. Radio-telemetry in 1983 indicated that spawning probably occurred in the Black Rocks area and that little movement occurs outside that area (Miller et al. 1984, Archer et al. 1984).

The major loss or decline of humpback chub has been due to habitat alterations by large dams, such as in the Grand Canyon or the Flaming Gorge area. Most present populations in the upper basin appear to be suffering from hybridization with roundtail chub (Valdez and Clemmer 1982), a less obvious but very effective method of eliminating a species. The major reason for this hybridization appears to be changes in flow. A population near De Beque is now apparently all hybrids with the roundtail chub (CRFRT 1982a, Valdez et al. 1982), and populations in Desolation Canyon of the Green River also appear to be primarily hybrids (Tyus et al. 1982). Reduced flows have tended to shift the distribution of roundtail chubs downstream from that observed historically (Jordan 1891); therefore, they are probably more abundant in humpback chub habitat than they were historically. Also, changes in flow have altered temperature patterns which may have also increased the likelihood of hybridization (Valdez and Clemmer 1982).

Effects on the Species

The Muddy Creek project would be too far upstream to affect humpback chub populations during construction. The major potential impact is the same as discussed for Colorado squawfish: alterations in flow that may impact the species or its habitat.

The Colorado squawfish discussion highlighted the flow changes that the project would have on the Colorado River. Alone, the project would not significantly affect present flow patterns except perhaps in the 15-mile reach. Because humpback chub are not known to utilize the 15-mile reach, impacts in flow patterns in that reach would not affect the species.

Humpback chub spawn during or immediately after high spring flow. Spawning is apparently the time when separation between humpback and roundtail chubs has broken down in many areas. This is probably due to increased numbers of roundtails in what was at one time exclusively humpback

chub habitat. Reduced spring flows appear to be one factor that may have created the present situation, and the reduction of spring flows by the Muddy Creek project would add to the cumulative effect of reduced flows at places such as Black Rocks and Westwater. The magnitude of flow depletions during the spring would be difficult to measure in the river at Black Rocks, but would continue the trend that has placed the species in its present position. The cumulative depletions of the Muddy Creek project, plus that of other recent or planned development (Table 3) would cause significant reductions (10 to 13 percent) in monthly and instantaneous flow in the Black Rocks area, a major population center for humpback chub. Average flows in May and June would be reduced 13 and 12 percent, respectively. These reductions may well alter temperature patterns or other parameters and continue favoring more roundtail chubs in that area, causing the increased breakdown of reproductive isolating mechanisms. This could result in more hybridization and perhaps the eventual swamping of the humpback chub population. It is possible that hybridization and fertile hybrids due to the close genetic lineage of these species has caused some humpback chub populations to be largely introgressed with roundtails. Desolation Canyon on the Green River may be an example. This could happen to the Colorado River populations also since some evidence of hybridization is apparent in these populations already. Therefore, the cumulative impact of the project may affect humpback chub.

Bonytail Chub

Life History and Distribution

The bonytail chub was originally distributed throughout the Colorado River basin in main channels and larger tributaries. Recently, bonytails have only been collected as adults in Lake Mohave of the lower basin, and sporadically in the Green and Yampa rivers (CRFRT 1982b). Additionally, one adult was collected at Black Rocks in the summer of 1984 (Kaeding 1984). The species' low numbers in the upper Colorado Basin suggest that it may be biologically extinct there.

Little is known of bonytail ecology. The species appeared to feed primarily on surface debris and spawned in early summer at river temperatures of about 18°C in the upper Green River (Vanicek and Kramer 1969). It used a variety of habitats, apparently preferring eddies and pools.

Reasons for decline of the bonytail throughout the Colorado River Basin are similar to those of the other large river fishes. Loss of habitat due to dams and reservoirs is the major factor. Loss of populations in the remaining free-flowing portions of the upper basin appear directly related to the completion of the large dams in the early 1960s, even though only flow alterations occurred in much of their habitat (Holden 1980, CRFRT 1982b). The loss of populations in the Green River below Flaming Gorge Dam are best documented and indicate flow changes as the most obvious factor (Holden 1980). Reproduction apparently stopped in 1963 when Flaming Gorge Dam was first closed. Flows were reduced dramatically, but temperatures remained near normal (Holden 1980). Apparently the bonytail was more susceptible to these changes in flow than the other large river fishes. The reduction in

bonytail populations in the upper Colorado River probably occurred prior to those in the Green River since none had been collected since the early 1900s until 1984 as noted above. This reduction is probably related to reductions in flow (CRFRT 1982b) since the Colorado River was reduced in flow before the Green River (Joseph et al. 1977).

The status of the bonytail is so precarious that the FWS is attempting to place any that are captured into a hatchery for brood stock. A plan was put in place during the summer of 1987 to expeditiously transport any bonytail from the river location of capture to Dexter or Willow Beach National Fish Hatcheries.

Effects on the Species

The bonytail chub is nearly extinct in the portions of the Colorado River of concern for this project, and therefore, any proposed depletion of flows, present or cumulative, may effect the species. Reduced flows in the river are the apparent reason for the bonytail's decline in the upper Colorado River. This project would continue the trend of reduced spring flows and altered flows at other times of the year. Hopes of recovering the species by hatchery rearing would be impacted by the continued alteration of flow in the river. Therefore, the species would be affected by the proposed projects directly, and recovery efforts could be impacted since no known acceptable habitat presently exists and, with increased depletion, any marginal habitats would likely disappear.

Razorback Sucker

Life History and Distribution

The razorback sucker is a candidate species for federal listing under the Endangered Species Act. It has been proposed for listing in the past and may be again in the near future. It was originally found in the main channels and larger tributaries of the Colorado River system. It is presently found in large numbers in several lower basin reservoirs and associated riverine areas and is found in the upper basin in the Green, Colorado, and San Juan rivers, as well as larger tributaries. In the upper Colorado River it is found from Lake Powell to near Rifle, Colorado, as well as in the Gunnison River below Delta, Colorado (Valdez et al. 1982, Kidd 1977). Concentrations have recently been found in flooded gravel pits near Grand Junction during high water, although they are seldom found in such numbers at other times of the year (Wick et al. 1982). The population in the De Beque area has not been well studied, and only a few specimens have been found in this area although large concentrations were noted several years ago (Kidd 1977, Sealing 1983). This population is cut off from other populations by the diversion dams between De Beque and Grand Junction.

Adult razorbacks are usually collected in flooded gravel pits or nearby river locations in the Colorado River. In the Green River they are generally collected in backwaters. These collections are ordinarily during high spring runoff. The species' apparent preferred habitat at that time is areas of low velocity and a sand-silt substrate (Wick et al. 1982). At

other times of the year they are not taken as commonly and use a variety of habitats, but still they are usually caught in slow areas. Radio-telemetry studies indicate use of runs near shore during spring, and over midchannel sand bars in summer (Tyus 1987).

Razorbacks spawn in May at river temperatures of 12 to 16°C, apparently over gravel bars in the river, although ripe adults have been taken from slow water areas (Wick et al. 1982). Few young razorbacks have been found in the Upper Colorado Basin, indicating either poor reproductive success or the inability to catch the young. Therefore, preferred habitat for young is not known. One potential larval razorback was collected at Parachute in 1983, about 10 miles above De Beque (Woodward-Clyde 1983).

Razorback reproduction has never been well documented in the lower Colorado River although recruitment has been suspected, especially in riverine habitats. It appears that 1984 was an unusual year in that larval razorback were found in Lake Mohave, as well as riverine portions of the lower Colorado River (Johnson 1984). Flows in the lower Colorado River were at record flood levels throughout 1983 and 1984 due to 1983 and 1984 runoff. It appears that the high flows may have stimulated reproduction of the razorback sucker.

Engineering-Science (1983) conducted larval fish surveys in the Colorado River at De Beque in the summer of 1983. They did not find any larval razorbacks or other candidate or listed species at any of their stations.

The major reason for the decline of the razorback is alteration of habitat by dams and impoundments. In the upper basin and the upper Colorado River, lack of reproduction appears to be the immediate problem (Wick et al. 1982). While reasons are not known, populations (especially in the upper Colorado River) have apparently declined since the 1950s (Kidd 1977), corresponding to the time of major flow alterations in the river. Razorback sucker and flannelmouth sucker hybrids have been collected in the Colorado River since the late 1800s (Jordan 1891, Valdez et al. 1982), and although hybrids are found today, hybridization does not appear to be a major factor affecting the well-being of the species. The same conclusion was recently reached by Buth et al. (1987) for the Lake Mohave population where introgression is present but in very small amounts.

Effects on the Species

Impacts to the razorback sucker would be similar to those discussed for Colorado squawfish. Flow alterations would be the major concern, although the 15-mile reach does not appear to be as important to razorbacks as it is to squawfish. Flow alterations caused by the Muddy Creek project alone would probably not affect the species since the magnitude of these alterations would be relatively small.

The cumulative effect of the Muddy Creek depletion plus other potential depletions as shown in Table 3 could be a problem for razorbacks. The cumulative depletions that would affect the area above Grand Junction are

those of the Cameo gauge. The amount of cumulative depletion is rather large and, therefore, may affect razorback sucker reproductive success.

It is difficult to say at this time whether the razorback population above Grand Junction is already doomed to extinction because the river has been depleted sufficiently so that the reproductive success is no longer achieved. If this is the case, the Muddy Creek project would make little additional difference. On the other hand, this project, along with other cumulative depletions, could reduce rates of reproduction success to levels that would cause the eventual loss of the population.

Razorback sucker populations below the Government Highline Dam would also be affected by the cumulative depletion of the Muddy Creek project and other planned water development projects. If, in fact, reduced flows are the major reason for the poor success of remaining populations, these cumulative impacts would exacerbate the present problems.

Therefore, the Muddy Creek project may affect razorback suckers through the cumulative depletion of Colorado River flows.

Proposed Actions and Measures to Minimize Impacts

During the past few years the FWS along with the upper Colorado River Basin states, the Bureau of Reclamation, and other water development and environmental interests have been working on a Conservation/Recovery Plan for the rare large river fishes. This new Recovery Implementation Plan has recently been approved by all agencies and is awaiting congressional approval for funding. The plan essentially allows for continued development of upper basin water in exchange for \$10 per acre-foot of average annual depletion to be used for research and recovery of the rare fish. At times, the FWS has also requested other conservation measures, such as providing storage for rare fish releases or conducting specific research studies, in lieu of the payment.

It is expected that conservation measures as directed by the new Recovery Plan will be implemented for this project for the rare fish. Compensation would be based on the approximately 10,000 acre-feet of use from Muddy Creek Reservoir, including about 6,000 acre-feet of use by Denver, 3,400 acre-feet by West Slope users, and about 500 acre-feet of water for the wetlands mitigation site. The use of water for the wetlands mitigation is the depletion, not the amount actually applied to the area, which would be about 1,000 acre-feet. In addition, other adjustments will need to be made for present irrigation use, evaporation from the reservoir, and other small potential changes in depletion. These estimates do not include adjustments for present use except where noted, evaporation from the reservoir, West Slope use return flow, or other small potential changes in depletion. A detailed depletion analysis is included in Appendix A. These conservation measures will hopefully assist in recovering the rare fish even in the face of continued depletion and alteration of Colorado River flows.

Wildlife

Bald Eagle

A dramatic decline in bald eagle (Haliaeetus leucocephalus) populations in the mid to late 1960s prompted the FWS to review the status of the bald eagle throughout its range. In 1967, the southern population of the bald eagle was listed as endangered throughout its range. In 1978, the northern population was given the status of endangered throughout the contiguous U.S., except in Washington, Oregon, Minnesota, Wisconsin, and Michigan, where it is considered threatened (National Audubon Society 1985).

The widespread use of pesticides such as DDT and its metabolites was the major factor in the decline of the bald eagle (Sprunt et al. 1973). Ingestion of pesticides resulted in eggshell thinning and lowered productivity (Wiemeyer et al. 1972). Since bald eagles take 4 to 5 years to reach sexual maturity and have a low reproductive potential, populations have been slow to recover following the prohibition of pesticides such as DDT by the federal government. Loss of breeding habitat has also been noted as a contributing factor to the species' demise.

Life History and Distribution

The bald eagle is a bird of prey inhabiting areas near coasts, rivers, and large bodies of water throughout North America. The northern population breeds across the northern half of the U.S., north through Canada to the Alaskan peninsula, and west through the Aleutian Islands to Bering Island (A.O.U. 1957). The southern population generally breeds and winters in the southern half of the U.S., but wintering ranges of the two populations may overlap. The total continental population is estimated at between 35,000 and 60,000 eagles, with the majority occurring in Alaska and Canada (Brown 1975). Large wintering populations occur in the Klamath Basin, California; in the midwestern states along the Mississippi, Missouri, Illinois, Platte, and Arkansas rivers; and in the Pacific Northwest encompassing Washington, Oregon, Idaho, and Montana.

Bald eagles migrate to wintering grounds from September to December and winter as far north as open water and food are available (U.S. Army Corps of Engineers 1979). Bald eagles wintering in the southwest tend to stay in the higher elevations where winter conditions tend to concentrate the prey base (Grubb and Kennedy 1982). Wintering eagles usually gather along lakes and major river systems but may use arid valleys. Bald eagles wintering in the Pacific Northwest concentrate along rivers and streams to exploit the food source provided by salmon runs. In the Midwest, important wintering areas include reservoirs supporting an abundant fish population, and waterfowl hunting areas which provide avian prey and carrion (Steenhof 1978).

Bald eagles gather in small to large aggregations on the wintering grounds, often using communal roosts, diurnal perches, and feeding areas (Grubb and Kennedy 1982). During winter, a larger variety of food is taken by eagles wintering in the Southwest (Grubb and Kennedy 1982, U.S. Army

Corps of Engineers 1979). Bald eagles remain in one area until the food source is depleted, then move to a new area in search of food (Servheen 1975). Northward movements occur from late January to May as the lakes and rivers thaw and pairs return to nesting territories (U.S. Army Corps of Engineers 1979).

The major components of habitat on wintering grounds include a food source and suitable trees for diurnal perching and roosting. Grubb and Kennedy (1982) described perching trees as those that afford good visibility of foraging areas. These trees are frequently either leafless or snags and are used during daylight hours near areas of daytime activity. Roost trees are used at night and frequently occur in dense stands of conifers, and are found in draws or small canyons, which provide protection from wind and weather (Grubb and Kennedy 1982). Perching sites are generally not limited, but roost trees can be limiting and may be found several miles from areas of daytime activities.

Bald eagles rely on open water as a source of fish, but food sources also include carrion, waterfowl, and lagomorphs (Grubb and Kennedy 1982). In Nevada, Utah, and portions of western Colorado, bald eagle presence in some areas is not related to the presence of water (USDI-BOR 1981).

Human disturbance can adversely affect use of important wintering areas (Stalmaster and Newman 1978). Vegetation buffer zones decreasing the line-of-sight contact between eagles and humans allows closer presence of humans without disrupting eagle feeding and perching activities. Stalmaster and Newman (1978) recommend vegetation zones 225 to 300 feet wide to protect critical wintering areas, including roost trees and important feeding areas.

Presence in the Area of Concern

No bald eagles were observed within the Muddy Creek study area during raptor surveys conducted by BIO/WEST in 1985 and 1986. No nests were reported as present in the area by the CDOW, BLM, or FWS. However, it is known that bald eagles are occasional visitors to the area during migration (Freddy 1986). The study area is in close proximity (1 mile) to the Colorado River, increasing the likelihood of use by bald eagles, particularly during winter months. Bald eagles are commonly reported within 10 miles north and south of Kremmling along the Colorado River (Cesar 1986).

The bald eagle can also be found along stretches of the streams above Dillon Reservoir, near both Dillon and Green Mountain reservoirs, and along portions of the Blue River, but much less commonly than along the Colorado River. The peak winter count of wintering bald eagles was two between Kremmling and Green Mountain Reservoir (Fisher et al. 1981). No information was given for wintering eagles above Green Mountain Reservoir from that study.

Effects on the Species

No deleterious effects on existing individuals are anticipated at the Muddy Creek study area as a result of building a reservoir, nor would

critical or important bald eagle habitat be affected. The proposed reservoir would likely provide additional food sources and better general bald eagle habitat. Muddy Creek below the dam would stay ice free, providing a good winter food gathering site. Cottonwood trees are already present but additional planting of cottonwoods is also planned as part of the wetland mitigation plan (USDA-FS 1988). Therefore, Muddy Creek may affect bald eagles beneficially by creating winter foraging habitat.

Human disturbance of bald eagles could potentially become a problem, since an increase in visitor days is forecast. Several studies have shown that human disturbances have a negative effect on wintering bald eagles (Hugie 1984, Stalmaster and Newman 1978, Steenhof 1978). However, since the vast majority of the visitation would occur during summer months, no additional disturbance to wintering bald eagles is expected.

Whooping Crane

The whooping crane (Grus americana) was originally protected under the Migratory Bird Treaty Act of 1916, but declining populations led to its placement on the federal endangered species list on March 11, 1967. To date, the whooping crane has shown improved status as a result of active management, but despite the unprecedented efforts and almost total protection, the recovery of the wild population has been slow and erratic and numbers are still alarmingly low (King 1977).

Life History and Distribution

There are two populations of whooping cranes in the western U.S. One population consists of the remaining wild whooping cranes. This group of birds nests in Wood Buffalo National Park, Alberta-Northwest Territories, Canada, and winters in Aransas National Wildlife Refuge, Texas. They migrate between these areas twice a year but members of this group of whooping cranes are never found west of Texas, Oklahoma, Kansas, Nebraska, and the Dakotas.

The other population is a small group of whooping cranes that have been cross-fostered by greater sandhill cranes (Grus canadensis tabida). In May 1975, officials of the Canadian Wildlife Service and the United States FWS began a cooperative experiment to reintroduce whooping cranes into the Rocky Mountain area (Drewien and Bizeau 1977). The reintroduction technique involved collecting wild whooping crane eggs in Wood Buffalo National Park, transporting them to Gray's Lake National Wildlife Refuge, Idaho, and placing them into nests of sandhill cranes. From studies of winter counts of whooping cranes at Aransas National Wildlife Refuge from 1939 to 1960, it was determined that one egg could be removed from each whooping crane nest with little impact on the wild population (Novakowski 1966, Drewien and Bizeau 1977).

Whooping cranes do not reach sexual maturity for 4 to 5 years (Kepler 1977). Though the foster program began in 1975, none of the cross-fostered whooping cranes has yet paired and nested. Cross-fostered whooping cranes may imprint on their foster parents or in other, perhaps behavioral, ways be

unable to recognize other whoopers as potential mates for reproduction. Since mating has not occurred areas of potential nesting are not known.

Cross-fostered whooping cranes migrate with sandhill cranes to and from nesting and wintering grounds. The Gray's Lake sandhill crane population winters in and around Bosque del Apache National Wildlife Refuge, New Mexico (Drewien and Bizeau 1977, Lewis 1986). They migrate across the southwest corner of Wyoming, the northeast corner of Utah, through Colorado and into New Mexico along the Rio Grande. There are between 25 and 30 cross-fostered whooping cranes migrating with this population of sandhill cranes (Lewis 1986). They feed in grain fields and wet pastures on the wintering grounds and roost in shallow rivers at night. Whooping cranes normally occupy habitat with a larger aquatic component than sandhill cranes, especially on wintering grounds where much of their food consists of aquatic organisms (Drewien and Bizeau 1977). However, whooping cranes reared by sandhill parents have adapted to using grain crops as a principal food source during much of the year (Drewien and Bizeau 1977).

Whooping cranes are native to wetland habitats. Most of their original nesting and wintering habitat has been drained for human settlement and development (Allen 1952, Archibald 1977, Halliday 1978), which has contributed substantially to the decimation of the population. For this reason, an attempt has been made to reestablish whooping crane populations in parts of their original range, especially in the Rocky Mountain Region where there are numerous wildlife refuges and other protected areas.

Mackenzie (1977) claims that sufficient space for both nesting and winter feeding is a major limiting factor since each pair requires undisturbed marsh of approximately 1,000 acres to nest and 400 to 600 acres for winter feeding territory. However, several factors that would enhance their potential for survival include state and federal protection, the retiring and wary nature of the species, the duration of parental care of the young, the ability of adult whooping cranes to ward off predators (except humans), and the foster parent program (Mackenzie 1977). Establishing populations of whooping cranes in parts of their original range would help prevent the main population from perishing should an event such as disease, toxic spills, or natural disasters occur on their wintering or nesting grounds (Erickson 1976). According to Archibald (1977), if there were a disaster and marshes used by whooping cranes were destroyed, feeding stations could be established in a dry, secure area and cranes could be flushed toward the stations. Feeding stations have been used successfully for other species of cranes throughout the world (Archibald 1977).

Cross-fostered whooping cranes migrating to and from wintering grounds with sandhill cranes follow the Rio Grande south from Alamosa, Colorado into New Mexico to wintering grounds at Bosque del Apache National Wildlife Refuge (Drewien and Bizeau 1977), south of Albuquerque. They have been reported along portions of the Colorado River during migration.

Presence in the Area of Concern

Freddy (1986), a research biologist for CDOW, and Cesar (1986), a wildlife biologist for the Bureau of Land Management, reported that greater sandhill cranes, a Colorado state endangered species, often use the irrigated and dry meadows along Muddy Creek during spring and early summer. However, no records of whooping cranes accompanying those sandhill cranes were found. Freddy (1986) indicated that a single whooping crane was sighted along Muddy Creek during the spring of 1984, but that no subsequent sightings have been reported.

Effects On The Species

Since the cross-fostered whooping cranes do not use any area within the proposed project with any consistency, no direct or indirect effects are anticipated.

Since no effect to the whooping cranes or their habitat is anticipated as a result of this proposed project, no addition to the cumulative effects on the species is anticipated.

Proposed Actions and Measures to Minimize Impacts

For protection of the bald eagle, construction personnel should be prohibited from carrying firearms while working on the project. No actions or measures would be required for protection of the whooping crane, since cranes do not use the proposed expansion area.

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APPENDIX A

DEPLETION ANALYSIS

MEMORANDUM

To: Bob Green and George Smith, USFWS

From: Pete Lagasse

Date: October 28, 1988

Subject: Hydrologic Data for Biological Opinion on Rock Creek/Muddy Creek Reservoir EIS

The Supplemental Draft EIS on Rock Creek/Muddy Creek Reservoirs was issued for agency and public comment in August 1988. Comments are due on November 25, 1988. The U. S. Forest Service (Routt) and BLM (Kremmling) are co-lead agencies for the NEPA process. A draft Biological Assessment (BA) for Muddy Creek (the preferred alternative) has been prepared and will be submitted for USFWS coordination in late October 1988.

Because of a "may affect" determination for rare fish, it is expected that conservation measures as directed by the Recovery Program will be required. The BA (page 46) provides a preliminary estimate that compensation would be based on about 10,000 AF of average annual depletion from Muddy Creek Reservoir, with about 6000 AF of use by Denver, and about 3400 AF of use by West Slope users, and approximately 500 AF required for wetlands mitigation below the dam. These estimates did not include adjustments for present use, evaporation from the reservoir, West Slope use return flows, or other small potential changes in depletion.

Based on discussion with you on October 12, it is apparent that some direct coordination on hydrologic issues would assist you in your support of the USFWS Biological Opinion. This memo contains information to support your hydrologic analysis.

The BA presents information extracted from the SDEIS on reservoir operations, the Metro Denver Lease (East Slope or short-term) demand, the West Slope (long-term) demand, and a tabular summary of flow changes at Dotsero (pages 11-26). I've included a copy of those sections of the BA as Attachment 1 for your reference. The data in Attachment 1 have not been adjusted for depletions at the reservoir site or return flows from West Slope water use. The main stem flow stations in the SDEIS (Kremmling and Dotsero) are analyzed using the USBR Green Mountain model which we applied for the Green Mountain water marketing EIS and adapted for application to the Rock Creek/Muddy Creek projects. The assumption and approach of the Green Mountain model are summarized in Section 3.4.1.3 SDEIS and include historic operations during the 1962-1982 study period corrected to reflect full utilization of Denver's Dillon Reservoir - Roberts Tunnel water rights.

Memorandum
Page two
October 28, 1988

RCI prepared a detailed depletion analysis for Muddy Creek Reservoir and summarized the results in a memo on October 6, 1988 (Attachment 2). That analysis considered net depletions attributable to reservoir operations and the reservoir site, including the wetlands mitigation site downstream. The average annual net project depletions would be 7864 AF for the East Slope demand and 6568 AF for the West Slope demand. However, the analysis did not consider change in storage in the reservoir during a given operational period or provide a detailed breakout of monthly depletions.

After discussion with you on October 12, we prepared a detailed operational analysis of depletions attributable to Muddy Creek Reservoir based on worst case conditions - the Metro Denver Lease (East Slope) demand. This demand will be in effect for the first 25 years of reservoir operation under the River District - Denver Lease as discussed in Section 1.3.7 SDEIS. We have provided the analysis for the 1962-1982 period of record used in the SDEIS and have extended the analysis to Cameo. Based on existing water requests, all diversions and return flows as a result of water sales/exchanges made possible by the reservoir will take place above Cameo. That monthly depletion analysis for the Colorado River at Cameo is included in Attachment 3.

To facilitate your use of this data, I have included a Lotus spreadsheet file (version 2.01) on disc. The monthly changes in flows at Cameo are presented in column 9 in AF and column 10 in CFS. If you have any questions please call either me or Dave Frick at RCI. If it would help, we can meet in your office to discuss the attached material.

PFL:lg

Attachments

M E M O R A N D U M

Date: October 6, 1988

To: Job File: 1334

From: George Palos

Subject: Depletions Attributable to the Muddy Creek Reservoir Project

1. Depletion estimates were made for the two alternatives analyzed in the EIS:
 - a. considering the Denver lease with west slope use
 - b. considering only west slope use
2. Project depletion has two components; one being the increased water losses at the reservoir site and mitigation areas and the water consumption associated to water sales from the project. Depletions here refer to those occurring to the Colorado River Basin.
3. In determining depletions of the in-basin water sales, it was assumed that 50% of the water will be consumed and the rest will remain in the basin as return flows.
4. Depletions at the project site were determined by comparing water losses and consumption from the existing land covers on the site with those occurring from areas affected by the project.

It was assumed that over the winter period of November through April depletions are unaffected by the project. Therefore, the comparative analysis was limited to the May through October period.

5. The project site depletions were estimated based upon the following land use areas:

<u>Pre-project uses:</u>	Inundation Area	Other Affected Areas	Total
non-irrigated meadows	559	72	631
naturally irrigated	654	3	657
irrigated pastures	168	0	168
riparian willow, cottonwood	41	0	41
creek water surface	17	1	18
standing water surface	<u>8</u>	<u>0</u>	<u>8</u>
Totals	1447	76	1523 ac
future mitigation area			175 ac

Post completion uses:

standing water surface in reservoir up to	1447 acres
new mitigation lakes	8 acres
non-irrigated other areas	76 acres
riparian willow, cottonwood	48 acres
irrigated wetland	119 acres
exposed lake shore area, defined by operation of reservoir.	

6. The May through October depletions were computed on a monthly basis with reservoir surface areas taken as the monthly average of the 21 years of operation analyses of the two scenarios, as follows:

	<u>Denver Lease</u>	<u>West Slope Use</u>
May	1374 ac	1319 ac
June	1436	1384
July	1398	1308
August	1314	1230
September	1276	1209
October	1252	1191

7. Water consumptions or accretions were computed based on the following monthly quantities shown in inches.

Type	Description	May	Jun	Jul	Aug	Sep	Oct
1	Eff.Ppt. + 1/3 (Ppt.-Eff.Ppt.)	1.174	1.019	1.201	1.387	1.092	.577
2	Pasture grass CU	2.602	3.856	4.872	4.195	2.606	1.153
3	1.25 x (Grass CU)	3.253	4.820	6.090	5.244	3.258	1.441
4	FWS evaporation	4.340	5.370	5.480	4.660	3.710	2.440
5	0.5 x (Ppt)	.745	.620	.710	.845	.695	.520
6	Ppt.	1.490	1.240	1.420	1.690	1.390	1.040
7	0.5 x (Grass CU)	1.301	1.928	2.436	2.098	1.303	.577

8. Depletion computations, with amounts shown in acre-feet units

8.1. Pre-project depletions

Line	Area Description	Depl.	Acres	Depletions (af)						Total
		Type		May	Jun	Jul	Aug	Sept	Oct	
1.	non-irrig. meadows	1	631	62	54	63	73	57	30	339
2.	irrig. & subirrig.	2	825	179	265	335	288	179	79	1325
3.	riparian veg.	3	41	11	16	21	18	11	5	82
4.	water surfaces	4	26	9	12	12	10	8	5	56
5.	future mitig. area	7	175	19	28	36	31	19	8	141
Total										1943

8.2.1. Project depletions with Metro Denver Lease

Line	Area Description	Depl.	Acres	Depletions (af)						Total
		Type		May	Jun	Jul	Aug	Sep	Oct	
1.	water surf. area ac	N/A	N/A	1374	1436	1398	1314	1276	1252	-----
2.	water surf. evap.	4	line 1	497	643	638	510	395	255	2938
3.	ppt. on water surf.	-6	line 1	-171	-148	-165	-185	-152	-109	-930
4.	non-irrig. acres	1	76	7	6	8	9	7	4	41
5.	exposed shore area ac	N/A	N/A	81	19	57	141	179	203	-----
6.	exposed shore	-5	line 5	-5	-1	-3	-10	-10	-9	-38
7.	riparian veg.	3	48	13	19	24	21	13	6	96
8.	irrig. wetland	2	119	26	38	48	42	26	11	191
Total										2298

Project consumption = 2298 - 1943 = 355 AF

8.2.2. Project depletions with west slope use only

Line	Area Description	Depl.	Acres	Depletions (af)						Total
		Type		May	Jun	Jul	Aug	Sep	Oct	
1.	wtr. surf. area ac	n/a	n/a	1319	1384	1308	1230	1209	1191	-----
2.	wtr. surf. evap.	4	line 1	477	619	597	478	374	242	2787
3.	ppt. on wtr. surf.	-6	line 1	-164	-143	-155	-173	-140	-103	-878
4.	non-irrig. areas	1	76	7	6	8	9	7	4	41
5.	exposed shore/area ac	n/a	n/a	128	63	139	217	238	256	-----
6.	exposed shore	-5	line 5	-8	-3	-8	-15	-14	-11	-59
7.	riparian veg.	3	48	13	19	24	21	13	6	96
8.	irrig. wetland	2	119	26	38	48	42	26	11	191
									Total	2178

Project consumption = 2178 - 1943 = 235 AF

- 9.1 Average annual project depletions were computed for the two alternatives based upon the summary tables of the 21 years reservoir operation studies.

	<u>Ac-ft</u>
East slope use (full depletion)	5826
Green Mtn. sales (50% consumption)	183
West slope sales (50% consumption)	1500
Res. site new depletions	<u>355</u>
Total:	7864 AF

- 9.2 Total West slope use:

	<u>Ac-ft</u>
Scheduled sales (50% consumption)	6333
Res. site new depletions	<u>235</u>
Total	6568 AF

Metro Denver Lease Demand Analysis, Muddy Creek Reservoir with Depletion Analysis (10/24/88)
Colorado River At Cameo

Water Year	Month	Total Inflow Muddy Creek	Release For Green Shortages		Total Reservoir Releases	Full Fill Deficit	Net Deplet. from Green Mnt. Sales Shortage	Net Deplet. from Add'l West Slope Sales	Net Reservoir Site Depletions	Change In Flows (AF)	Change In Flows (cfs)
		1	2	3	4	5	6	7	8	9	10
1962	OCT	4722			799	0	0	125	31	-4079	-66.3
	NOV	3610			3660	0	0	125	0	125	2.1
	DEC	2151			2401	0	0	125	0	125	2.0
	JAN	3259			3509	0	0	125	0	125	2.0
	FEB	2753			3003	0	0	125	0	125	2.2
	MAR	1760			2010	0	0	125	0	125	2.0
	APR	32049			28002	0	0	125	0	-4172	-70.1
	MAY	32951			32951	0	0	125	87	-212	-3.5
	JUN	14157			14157	0	0	125	182	-307	-5.2
	JUL	6663			6663	0	0	125	83	-208	-3.4
	AUG	3633			6150	0	0	125	-33	2425	39.4
	SEPT	1850			2100	0	0	125	5	120	2.0
1963	OCT	0			799	0	0	125	31	643	10.5
	NOV	0			774	0	0	125	0	643	10.9
	DEC	0			799	0	0	125	0	674	11.0
	JAN	2082			2332	0	0	125	0	125	2.0
	FEB	2537			2837	0	0	125	0	125	2.2
	MAR	4731			4981	0	0	125	0	125	2.0
	APR	6369			6819	0	0	125	0	125	2.1
	MAY	6840			2700	0	0	125	87	-6352	-103.3
	JUN	2251			2251	0	0	125	182	-307	-5.2
	JUL	1050			6150	3070	0	125	83	1832	29.6
	AUG	2054			10034	7730	0	125	-33	158	2.6
	SEPT	121			7201	6830	0	125	5	120	2.0
1964	OCT	966			9606	8390	0	125	31	94	1.5
	NOV	1647			1897	0	0	125	0	125	2.1
	DEC	1354			1604	0	0	125	0	125	2.0
	JAN	1307			1557	0	0	125	0	125	2.0
	FEB	1260			1510	0	0	125	0	125	2.2
	MAR	1669			1919	0	0	125	0	125	2.0
	APR	4736			4986	0	0	125	0	125	2.1
	MAY	12348			799	0	0	125	87	-11761	-191.3
	JUN	8971			774	0	0	125	182	-8504	-142.9
	JUL	3558			6150	0	0	125	83	2384	38.8
	AUG	5331			8371	2730	0	125	-33	158	2.6
	SEPT	732			14122	13140	0	125	5	120	2.0
1965	OCT	1109			3179	1820	0	125	31	94	1.5
	NOV	1362			1612	0	0	125	0	125	2.1
	DEC	1145			1395	0	0	125	0	125	2.0
	JAN	1064			1314	0	0	125	0	125	2.0
	FEB	998			1248	0	0	125	0	125	2.2
	MAR	941			1191	0	0	125	0	125	2.0
	APR	7957			8207	0	0	125	0	125	2.1
	MAY	21366			799	0	0	125	87	-20779	-337.9
	JUN	20785			8206	0	0	125	182	-12886	-216.6
	JUL	5986			6150	0	0	125	83	-44	-0.7
	AUG	6087			6150	0	0	125	-33	-29	-0.5
	SEPT	3420			3670	0	0	125	5	120	2.0

Metro Denver Lease Demand Analysis, Muddy Creek Reservoir with Depletion Analysis (10/24/88)
Colorado River At Cameo

Water Year	Month	Total Inflow Muddy Creek	Release For Green Shortages Above Dotsero Below Dotsero		Total Reservoir Releases	Full Fill Deficit	Net Deplet. from Green Mnt. Sales Shortage	Net Deplet. from Add'l West Slope Sales	Net Reservoir Site Depletions	Change In Flows (AF)	Change In Flows (cfs)
		1	2	3	4	5	6	7	8	9	10
1966	OCT	3709			3958	0	0	125	31	94	1.5
	NOV	3227			3477	0	0	125	0	125	2.1
	DEC	1603			1853	0	0	125	0	125	2.0
	JAN	2688			2938	0	0	125	0	125	2.0
	FEB	1652			1902	0	0	125	0	125	2.2
	MAR	3950			4200	0	0	125	0	125	2.0
	APR	4573			4823	0	0	125	0	125	2.1
	MAY	6686			4459	0	0	125	87	-2439	-39.7
	JUN	903			1153	0	0	125	182	-57	-1.0
	JUL	316			6150	1040	0	125	83	4586	74.6
	AUG	221			6150	4340	0	125	-33	1497	24.3
	SEPT	902			5222	4070	0	125	5	120	2.0
1967	OCT	2469			2719	0	0	125	31	94	1.5
	NOV	2538			2788	0	0	125	0	125	2.1
	DEC	1553			1803	0	0	125	0	125	2.0
	JAN	1460			1710	0	0	125	0	125	2.0
	FEB	1776			2026	0	0	125	0	125	2.2
	MAR	4895			5145	0	0	125	0	125	2.0
	APR	5927			6177	0	0	125	0	125	2.1
	MAY	9467			799	0	0	125	87	-8880	-144.4
	JUN	10707			1291	0	0	125	182	-9723	-163.4
	JUL	3610			6150	0	0	125	83	2332	37.9
	AUG	3026			7556	4280	0	125	-33	158	2.6
	SEPT	2772			6572	5550	0	125	5	120	2.0
1968	OCT	1931			6461	4280	0	125	31	94	1.5
	NOV	2289			2539	0	0	125	0	125	2.1
	DEC	2147			2397	0	0	125	0	125	2.0
	JAN	2337			3087	0	0	125	0	125	2.0
	FEB	2873			3123	0	0	125	0	125	2.2
	MAR	2998			3248	0	0	125	0	125	2.0
	APR	5889			6139	0	0	125	0	125	2.1
	MAY	12877			799	0	0	125	87	-12290	-199.9
	JUN	16658			9836	0	0	125	182	-7129	-119.8
	JUL	5778			6150	0	0	125	83	164	2.7
	AUG	6923			6551	0	0	125	-33	-464	-7.5
	SEPT	3044			3294	0	0	125	5	120	2.0
1969	OCT	2768			3018	0	0	125	31	94	1.5
	NOV	3822			4072	0	0	125	0	125	2.1
	DEC	3292			3542	0	0	125	0	125	2.0
	JAN	3029			3279	0	0	125	0	125	2.0
	FEB	2616			2866	0	0	125	0	125	2.2
	MAR	3190			3440	0	0	125	0	125	2.0
	APR	9599			7849	0	0	125	0	-1875	-31.5
	MAY	11710			11710	0	0	125	87	-212	-3.4
	JUN	8580			8580	0	0	125	182	-307	-5.2
	JUL	4208			6150	0	0	125	83	1734	28.2
	AUG	1063			6150	0	0	125	-33	4990	81.2
	SEPT	1581			1831	0	0	125	5	120	2.0

Metro Denver Lease Demand Analysis, Muddy Creek Reservoir with Depletion Analysis (10/24/88)
Colorado River At Cameo

Water Year	Month	Total Inflow Muddy Creek	Release For Green Shortages		Total Reservoir Releases	Full Fill Deficit	Net Deplet. from Green Mnt. Sales Shortage	Net Deplet. from Add'l West Slope Sales	Net Reservoir Site Depletions	Change In Flows (AF)	Change In Flows (cfs)
		1	2	3	4	5	6	7	8	9	10
	OCT	4697			4947	0	0	125	31	94	1.5
	NOV	3617			3867	0	0	125	0	125	2.1
	DEC	3528			3778	0	0	125	0	125	2.0
	JAN	3694			3944	0	0	125	0	125	2.0
	FEB	2668			2918	0	0	125	0	125	2.2
	MAR	3849			4099	0	0	125	0	125	2.0
1970	APR	9432			9682	0	0	125	0	125	2.1
	MAY	30386			21361	0	0	125	87	-9237	-150.2
	JUN	20691			20691	0	0	125	182	-307	-5.2
	JUL	7658			7658	0	0	125	83	-208	-3.4
	AUG	4563			6150	0	0	125	-33	1495	24.3
	SEPT	1682			1931	0	0	125	5	119	2.0
	OCT	6076			6326	0	0	125	31	94	1.5
	NOV	6359			6609	0	0	125	0	125	2.1
	DEC	5239			5489	0	0	125	0	125	2.0
	JAN	5195			5445	0	0	125	0	125	2.0
	FEB	5538			5788	0	0	125	0	125	2.2
	MAR	6784			7034	0	0	125	0	125	2.0
1971	APR	8599			8262	0	0	125	0	-3462	-58.2
	MAY	13026			13026	0	0	125	87	-212	-3.4
	JUN	18228			18228	0	0	125	182	-307	-5.2
	JUL	19612			19612	0	0	125	83	-208	-3.4
	AUG	9425			9675	0	0	125	-33	158	2.6
	SEPT	7160			7410	0	0	125	5	120	2.0
	OCT	3673			4123	0	0	125	31	94	1.5
	NOV	2595			2845	0	0	125	0	125	2.1
	DEC	3409			3659	0	0	125	0	125	2.0
	JAN	1738			1988	0	0	125	0	125	2.0
	FEB	2448			2698	0	0	125	0	125	2.2
	MAR	4783			5033	0	0	125	0	125	2.0
1972	APR	7319			7569	0	0	125	0	125	2.1
	MAY	17020			14770	0	0	125	87	-2462	-40.0
	JUN	15567			15567	0	0	125	182	-307	-5.2
	JUL	4390			6150	0	0	125	83	1552	25.2
	AUG	2535			6150	0	0	125	-33	3523	57.3
	SEPT	2322			2572	0	0	125	5	120	2.0
	OCT	3403			3653	0	0	125	31	94	1.5
	NOV	2346			2596	0	0	125	0	125	2.1
	DEC	1074			1324	0	0	125	0	125	2.0
	JAN	657			907	0	0	125	0	125	2.0
	FEB	485			735	0	0	125	0	125	2.2
	MAR	853			1103	0	0	125	0	125	2.0
1973	APR	6358			6608	0	0	125	0	125	2.1
	MAY	27733			20358	0	0	125	87	-7587	-123.4
	JUN	17740			17740	0	0	125	182	-307	-5.2
	JUL	9127			9127	0	0	125	83	-208	-3.4
	AUG	5471			6150	0	0	125	-33	587	9.5
	SEPT	2226			2476	0	0	125	5	120	2.0

Metro Denver Lease Demand Analysis, Muddy Creek Reservoir with Depletion Analysis (10/24/88)
Colorado River At Cameo

Water Year	Month	Total Inflow Muddy Creek	Release For Green Shortages		Total Reservoir Releases	Full Fill Deficit	Net Deplet. from Green Mnt. Sales Shortage	Net Deplet. from Add'l West Slope Sales	Net Reservoir Site Depletions	Change In Flows (AF)	Change In Flows (cfs)
		1	2	3	4	5	6	7	8	9	10
1974	OCT	2270			2520	0	0	125	31	94	1.5
	NOV	2371			3121	0	0	125	0	125	2.1
	DEC	2902			3152	0	0	125	0	125	2.0
	JAN	2930			3180	0	0	125	0	125	2.0
	FEB	2223			2473	0	0	125	0	125	2.2
	MAR	4922			5172	0	0	125	0	125	2.0
	APR	8522			8772	0	0	125	0	125	2.1
	MAY	28724			26045	0	0	125	87	-2891	-47.0
	JUN	13395			13395	0	0	125	182	-307	-5.2
	JUL	6784			6784	0	0	125	83	-208	-3.4
	AUG	3292			6150	0	0	125	-33	2766	45.0
	SEPT	443			774	0	0	125	5	201	3.4
1975	OCT	2747			2997	0	0	125	31	94	1.5
	NOV	3071			3321	0	0	125	0	125	2.1
	DEC	2282			2532	0	0	125	0	125	2.0
	JAN	1647			2097	0	0	125	0	125	2.0
	FEB	2116			2366	0	0	125	0	125	2.2
	MAR	2947			3197	0	0	125	0	125	2.0
	APR	5862			6132	0	0	125	0	125	2.1
	MAY	20274			15336	0	0	125	87	-5150	-83.8
	JUN	23472			23472	0	0	125	182	-307	-5.2
	JUL	7515			7515	0	0	125	83	-208	-3.4
	AUG	4777			6150	0	0	125	-33	1281	20.8
	SEPT	2153			2403	0	0	125	5	120	2.0
1976	OCT	3022			3272	0	0	125	31	94	1.5
	NOV	3468			3718	0	0	125	0	125	2.1
	DEC	4171			4421	0	0	125	0	125	2.0
	JAN	3713			3963	0	0	125	0	125	2.0
	FEB	3148			3398	0	0	125	0	125	2.2
	MAR	5096			5346	0	0	125	0	125	2.0
	APR	7723			7973	0	0	125	0	125	2.1
	MAY	17937			14564	0	0	125	87	-3585	-58.3
	JUN	7876			7876	0	0	125	182	-307	-5.2
	JUL	3467			6150	0	0	125	83	2475	40.3
	AUG	3296			6150	0	0	125	-33	2762	44.9
	SEPT	1850			2100	0	0	125	5	120	2.0
1977	OCT	2408			2658	0	0	125	31	94	1.5
	NOV	1870			2120	0	0	125	0	125	2.1
	DEC	3029			3279	0	0	125	0	125	2.0
	JAN	628			878	0	0	125	0	125	2.0
	FEB	1656			1906	0	0	125	0	125	2.2
	MAR	1994			2244	0	0	125	0	125	2.0
	APR	5259			5509	0	0	125	0	125	2.1
	MAY	4138			4388	0	0	125	87	38	0.6
	JUN	845			1095	0	0	125	182	-57	-1.0
	JUL	1011			12981	11720	0	125	83	42	0.7
	AUG	1677	477	978	21657	18280	728	125	-33	980	14.3
	SEPT	1023	575	1345	3193	0	960	125	5	1080	18.2

Metro Denver Lease Demand Analysis, Muddy Creek Reservoir with Depletion Analysis (10/24/88)
Colorado River At Cameo

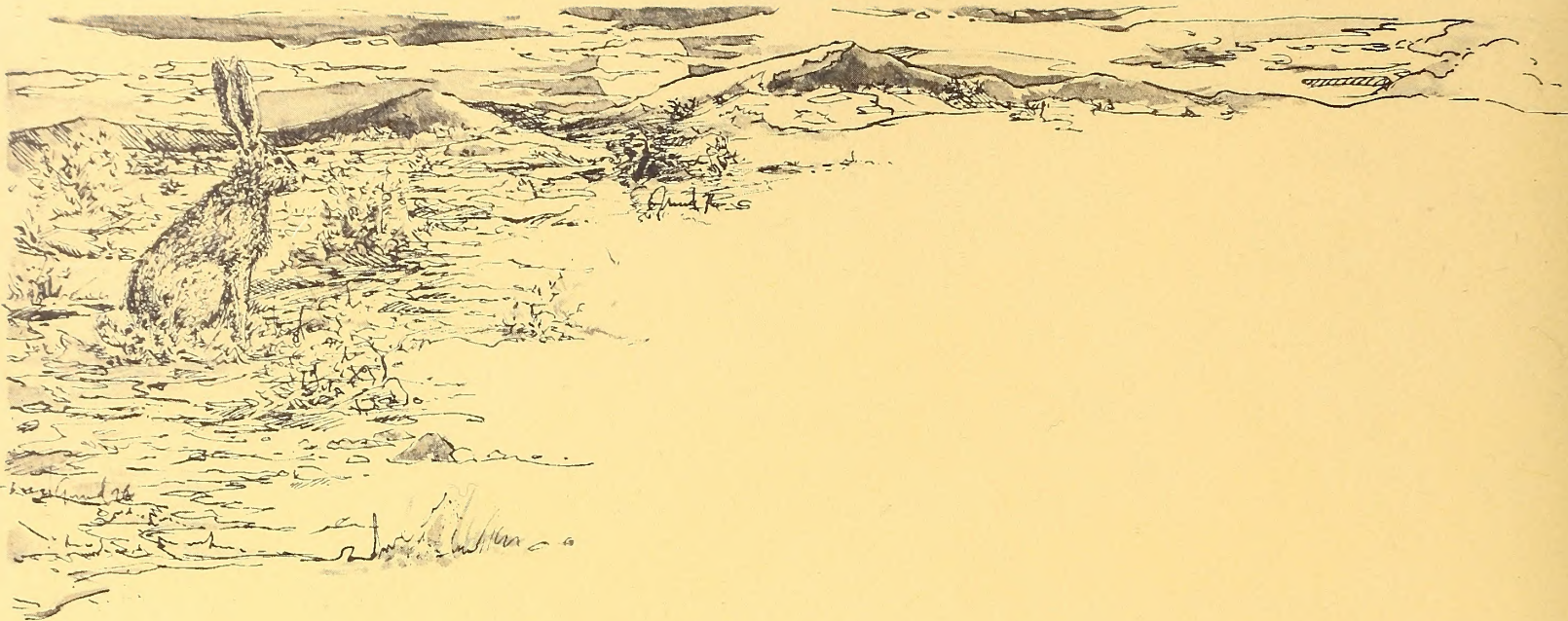
Water Year	Month	Total Inflow Muddy Creek	Release For Green Shortages		Total Reservoir Releases	Full Fill Deficit	Net Deplet. from Green Mnt. Sales Shortage	Net Deplet. from Add'l West Slope Sales	Net Reservoir Site Depletions	Change In Flows (AF)	Change In Flows (cfs)
		1	2	3	4	5	6	7	8	9	10
	OCT	2220	335	975	3780	0	655	125	31	749	12.2
	NOV	1915	830	0	2995	0	415	125	0	540	9.1
	DEC	1484	745	0	2474	0	373	125	0	493	8.0
	JAN	2411	520	0	3181	0	250	125	0	385	6.3
	FEB	2216	245	0	2706	0	123	125	0	243	4.3
	MAR	4400	145	0	4790	0	73	125	0	192	3.1
1978	APR	10907	40	480	11687	0	250	125	0	385	6.6
	MAY	25519			799	0	0	125	87	-24932	-405.5
	JUN	23485			774	0	0	125	182	-23018	-386.8
	JUL	7426			6540	0	0	125	83	-994	-16.2
	AUG	3026			6150	1330	0	125	-33	1702	27.7
	SEPT	1052			3322	2030	0	125	5	110	1.8
	OCT	2656			2906	0	0	125	31	94	1.5
	NOV	3110			3360	0	0	125	0	125	2.1
	DEC	3836			4086	0	0	125	0	125	2.0
	JAN	3149			3399	0	0	125	0	125	2.0
	FEB	2943			3193	0	0	125	0	125	2.2
	MAR	2417			2667	0	0	125	0	125	2.0
1979	APR	9023			9273	0	0	125	0	125	2.1
	MAY	36715			29570	0	0	125	87	-7357	-119.6
	JUN	25084			25084	0	0	125	182	-307	-5.2
	JUL	5616			6150	0	0	125	83	326	5.3
	AUG	4370			6150	0	0	125	-33	1688	27.5
	SEPT	234			774	0	0	125	5	410	6.9
	OCT	1660			1910	0	0	125	31	94	1.5
	NOV	2823			3073	0	0	125	0	125	2.1
	DEC	2326			2576	0	0	125	0	125	2.0
	JAN	2835			3085	0	0	125	0	125	2.0
	FEB	2494			2744	0	0	125	0	125	2.2
	MAR	2368			2618	0	0	125	0	125	2.0
1980	APR	8975			9225	0	0	125	0	125	2.1
	MAY	31501			26896	0	0	125	87	-4817	-78.3
	JUN	10085			10085	0	0	125	182	-307	-5.2
	JUL	4744			6150	0	0	125	83	1198	19.5
	AUG	4840			6150	0	0	125	-33	1218	19.8
	SEPT	1835			2085	0	0	125	5	120	2.0
	OCT	2875			3125	0	0	125	31	94	1.5
	NOV	2720			2970	0	0	125	0	125	2.1
	DEC	2311			2561	0	0	125	0	125	2.0
	JAN	2199			2449	0	0	125	0	125	2.0
	FEB	2871			3121	0	0	125	0	125	2.2
	MAR	2730			2980	0	0	125	0	125	2.0
1981	APR	3425			3675	0	0	125	0	125	2.1
	MAY	7067			2351	0	0	125	87	-4928	-80.1
	JUN	4383			4383	0	0	125	182	-307	-5.2
	JUL	4704			6150	630	0	125	83	608	9.9
	AUG	2492			23772	21030	0	125	-33	158	2.6
	SEPT	2130			2380	0	0	125	5	120	2.0

Metro Denver Lease Demand Analysis, Muddy Creek Reservoir with Depletion Analysis (10/24/88)
Colorado River At Cameo

Water Year	Month	Total Inflow	Release For Green Shortages		Total Reservoir Releases	Full Fill Deficit	Net Deplet. from Green Mnt. Sales Shortage	Net Deplet. from Add'l West Slope Sales	Net Reservoir Site Depletions	Change In Flows (AF)	Change In Flows (cfs)
			Above Dotsero	Below Dotsero							
		1	2	3	4	5	6	7	8	9	10
	OCT	3630			3880	0	0	125	31	94	1.5
	NOV	3257			3507	0	0	125	0	125	2.1
	DEC	2970			3220	0	0	125	0	125	2.0
	JAN	3690			3940	0	0	125	0	125	2.0
	FEB	2695			2945	0	0	125	0	125	2.2
	MAR	1451			1701	0	0	125	0	125	2.0
1982	APR	2558			2808	0	0	125	0	125	2.1
	MAY	16608			799	0	0	125	87	-16021	-260.6
	JUN	17756			8839	0	0	125	182	-9224	-155.0
	JUL	6502			6502	0	0	125	83	-208	-3.4
	AUG	2424			6150	0	0	125	-33	3634	59.1
	SEPT	3053			774	0	0	125	5	-2409	-40.5

Metro Denver Lease Demand Analysis, Muddy Creek Reservoir with Depletion Analysis (10/24/83)
Colorado River At Cameo

Month	Total Inflow Muddy Creek	Release For Green Shortages		Total Reservoir Releases	Full Fill Deficit	Net Deplet. from Green Mnt. Sales Shortage	Net Deplet. from Add'l West Slope Sales	Net Reservoir Site Depletions	Change In Flows (AF)	Change In Flows (cfs)
	1	2	3	4	5	6	7	8	9	10
62	109558	0	0	105606	0	0	1500	355	-5807	-97
63	30285	0	0	47677	17630	0	1500	355	-2093	-34
64	43873	0	0	53295	24320	0	1500	355	-16759	-277
65	72220	0	0	43121	1820	0	1500	355	-32774	-540
66	30429	0	0	46286	9450	0	1500	355	4552	74
67	50200	0	0	46737	9830	0	1500	355	-15148	-251
68	66244	0	0	53625	4280	0	1500	355	-18754	-308
69	55463	0	0	62487	0	0	1500	355	5169	83
70	96465	0	0	91026	0	0	1500	355	-7294	-118
71	111241	0	0	109904	0	0	1500	355	-3192	-54
72	67999	0	0	73123	0	0	1500	355	3269	53
73	77473	0	0	72777	0	0	1500	355	-6551	-106
74	79278	0	0	81537	0	0	1500	355	404	7
75	79083	0	0	77518	0	0	1500	355	-3420	-55
76	64767	0	0	68930	0	0	1500	355	2308	38
77	25538	1052	2323	61908	30000	1688	1500	355	2827	47
78	86061	2860	1455	49297	3360	2158	1500	355	-44136	-729
79	99153	0	0	96611	0	0	1500	355	-4397	-71
80	76486	0	0	76597	0	0	1500	355	-1744	-28
81	39907	0	0	59916	21660	0	1500	355	-3506	-57
82	66594	0	0	45065	0	0	1500	355	-23384	-386
age	68015	186	180	67764	5826	183	1500	355	-8116	-134
uan	111241	2860	2323	109904	30000	2158	1500	355	5169	83
uan	25538	0	0	43121	0	0	1500	355	-44136	-729



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